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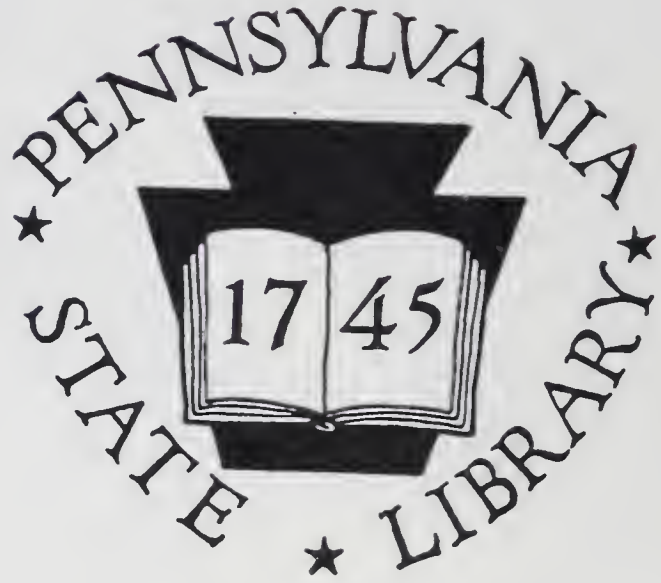

PROCEEDINGS

OF

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

VOL. V.

1889.

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CHARTER.

To the Court of Common Pleas No. 1, of Allegheny County, Pennsylvania:

We, the subscribers hereto, citizens of the Commonwealth of Pennsylvania, desirous of acquiring and enjoying the powers and immunities of a Corporation, or a body politic in law, do hereby associate ourselves under the articles, conditions and for the objects, and in the name, style and title herein set forth.

ARTICLE I.—This corporation shall be styled and named and bear the title of "ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA."

ART. II.—The object of this corporation shall be the advancement of engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among men of practical science.

ART. III.—Among the means to be employed for attaining these ends shall be periodical meetings for the discussion of scientific subjects and social intercourse, the reading of professional papers, and excursions to examine objects of engineering interest.

ART. IV.—Civil, mechanical and mining engineers, geologists, architects, managers and superintendents of railroads, mills and manufactories, and other persons engaged in scientific and mechanical pursuits pertaining to engineering, shall be eligible to membership in this corporation.

ART. V.—There shall be two classes of members, active and honorary. Active members shall be persons who are actively engaged in any pursuit above specified, and who will participate in promoting the interests of this Society, attend its meetings, present papers and vote at elections. Honorary members shall be persons who shall have attained eminence in any of the professions or departments of knowledge or labor mentioned in Article IV. hereof.

ART. VI.—Each person desirous of becoming a member shall be proposed by at least two members, and referred to the Board of Direction, and, when favorably reported, shall be elected by ballot at a regular meeting, upon receiving a majority of the votes cast, and shall become a member on the payment of his first dues, provided the same are paid within three months of his election. Honorary members shall be elected by a unanimous vote.

ART. VII.—The name of any member may be stricken from the list of members, upon its being so ordered by the Board of Direction, and by a vote of three-fourths of the members of this corporation present at any annual meeting; due notice, however, having first been given to said member of such action.

ART. VIII.—The officers of this corporation shall be a President, two Vice-Presidents, a Secretary, a Treasurer and four Directors. The President, one Vice-President, Secretary, Treasurer and two Directors shall be elected annually by ballot, by a majority of the votes cast at the annual meeting, and shall hold their offices until their successors are elected.

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The President, Vice-Presidents and Directors shall be eligible to but one re-election in succession. The offices of Secretary and Treasurer may be held by one person.

The President, and in his absence the senior Vice-President present, shall preside, and in case of their absence a President *pro tempore* shall be chosen.

ART. IX.—The Board of Direction shall be composed of the President, two Vice-Presidents and the Directors, elected by the members. They shall have the general management of the affairs of the corporation, shall hold monthly meetings at such times as they shall fix, and special meetings, when called for by the President or any two members of the Board of Direction, and shall report their transactions at each regular meeting.

They shall have power to fill vacancies in their own body, and the persons by them chosen shall continue in office until a successor is chosen, and a special election therefor to fill the office and term made vacant may be had at any regular meeting.

ART. X.—This corporation may make By-Laws not inconsistent herewith, nor with the laws of this Commonwealth.

WM. METCALF,
A. GOTTLIEB,
THOS. RODD,
E. M. BUTZ,
N. M. MCDOWELL,
WM. KENT,
J. H. HARLOW.

I hereby certify that I have examined the foregoing articles of Association of the Engineers' Society of Western Pennsylvania, and am of opinion that the objects, articles and conditions therein contained are lawful and not injurious to the community, and within the proper power of the Court of Common Pleas to confirm as an incorporation, under the laws of this Commonwealth.

M. A. WOODWARD,
Solicitor for Applicants.

In matter of the incorporation of the Engineers' Society of Western Pennsylvania. } Common Pleas of Allegheny County.

And now, to wit, this 21st day of February, 1880, the foregoing articles for the incorporation of the Engineers' Society of Western Pennsylvania being presented in open court, and perused and examined, and the objects, articles and conditions appearing lawful, and not injurious to the community, it is directed that the same be filed in the prothonotary's office of this court, and that notice thereof be inserted in the Pittsburg *Legal Journal and Commercial Gazette*, of this county, for three weeks, as required by law.

By the Court,
EDWIN H. STOWE, *P. J.*

In the matter of the incorporation of the Engineers' Society of Western Pennsylvania.

And now, to wit, March 20, 1880, the articles of incorporation of the Engineers' Society of Western Pennsylvania having been, February 21, 1888, filed in the office of the prothonotary of this court, and due notice by publication in the Pittsburg *Legal Journal and Commercial Gazette*, a daily newspaper of this county, made conformatory to law, and no exceptions being filed thereto; Therefore, on motion of M. A. Woodward, it is declared and decreed that the persons so associated under said articles shall, according to the said articles, and the conditions in said instrument set forth and contained, become and be a corporation or body politic in law. And it is further ordered and directed that said charter of incorporation shall be recorded in the office of recording deeds in said county, and on being so recorded the persons so associated, or meaning to associate, shall, according to the articles, objects and conditions in said instrument set forth, become and be a corporation or body politic in law, and in fact to have continuance by this name, style and title in said instrument provided and declared.

By the Court,

EDWIN H. STOWE, *P. J.*

State of Pennsylvania,
County of Allegheny. } *sct.*

Recorded in the office for the recording of deeds, etc., in and for said county, on the 20th day of March, A.D. 1880, in Charter Book, Vol. 6, page 277.

Witness my hand and the seal of said office, the day and year aforesaid.

R. J. RICHARDSON, *Recorder.*

BY-LAWS.

ARTICLE I.

Regular meetings for the reading of papers and discussion of scientific subjects shall be held on the THIRD TUESDAY OF EACH MONTH.

Special meetings may be called by the President, and shall be called at the request of five members in writing.

Notices of special meetings shall be mailed to each active member, at least one week in advance of said meeting.

Notices of special meetings shall contain a statement of the object for which the meeting is called, and no subject not stated in the notice shall be decided at any special meeting.

ARTICLE II.

SECTION 1. The following order of business shall be observed at the annual meeting:

1. Reading of minutes of last annual meeting.
2. Report of Treasurer.
3. Report of Secretary.
4. Annual report of the Board of Direction.
5. Reports of special committees.
6. Address of retiring President.
7. Election, and announcement of election of officers.
8. Adjournment.

SEC. 2. The following shall be the order of business for the regular meetings:

1. Reading of minutes of last regular, and of subsequent special meetings.
2. Report of the Board of Direction.
3. Election of new members.
4. Unfinished business.
5. Reports of committees.
6. New Business.
7. Miscellaneous announcements, papers, items, notes or communications.
8. Adjournment.

SEC. 3. In all questions arising at any meeting involving parliamentary rules, those adopted by the councils of Pittsburg shall be accepted as authority.

ARTICLE III.

The dues of members shall be five dollars per annum, payable in advance, at the annual meeting; *Provided, however*, that all members elected after the first day of July shall pay one-half of said amount, and receive the TRANSACTIONS of the current year.

Any member in arrears for one year or more may, at the discretion of the Board of Direction, be deprived of the privileges of the Society until said arrears have been paid.

ARTICLE IV.

Amendments to the By-Laws must be proposed in writing, by at least three members at one regular meeting, and adopted by a two-thirds vote at a subsequent regular meeting; providing written notice of such amendment be sent to each member with notice of meeting.

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OFFICERS FOR 1889.

PRESIDENT,

JOHN A. BRASHEAR, Observatory Avenue, Allegheny, Pa.

VICE-PRESIDENTS,

One Year.—W. L. SCAIFE, 28th and Smallman Streets, Pittsburg, Pa.

Two Years.—A. E. HUNT, 98 Fourth Avenue, Pittsburg, Pa.

DIRECTORS,

One Year.—T. P. ROBERTS, 53 Beech Street, Allegheny, Pa.

C. DAVIS, Court House, Pittsburg, Pa.

Two Years.—WM. METCALF, Crescent Steel Works.

MAX. J. BECKER, C. Eng., P., C. & St. L. Ry., Pittsburg, Pa.

SECRETARY,

S. M. WICKERSHAM, Pittsburg, Pa.

TREASURER,

A. E. FROST, 133 North Avenue, Allegheny, Pa.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

NINTH ANNUAL MEETING.

PITTSBURG, JANUARY 22D, 1889.

SOCIETY met at 8 o'clock P.M. at their rooms, Penn Building. President A. Dempster in the chair.

Vice-President W. L. Scaife, Directors A. E. Hunt, E. B. Taylor, T. P. Roberts, Charles Davis, and 44 members being present.

The minutes of the last annual meeting were read and approved.

A. E. Frost, Treasurer, then read his report, viz.:

REPORT OF TREASURER ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA FOR THE YEAR ENDING JANUARY 15TH, 1889.

Receipts.

January 17th, 1888, balance,	$161 69
Dues from 3 members to January, 1885,	15 00
" " 4 members to January, 1886,	20 00
" " 7 members to January, 1887,	35 00
" " 16 members to January, 1888,	80 00
" " 6 members to January, 1888 (one-half year),	15 00
" " 248 members to January, 1889,	1240 00
" " 11 members to January, 1889 (one-half year),	27 50
" " 3 members to January, 1890,	15 00
Other back dues,	9 50
Publications sold,	1 50
Lecture tickets (late return),	2 00
Total,	$1622 19

Expenditures.

Printing,	$501 75
Rent,	268 00
Salary of Secretary,	200 00
Postage and other office expenses,	140 65
Binding,	105 08
Periodicals, English and American,	79 80
Periodicals, German,	49 49
Stenographer,	65 00
Commissions on collections,	11 08
Permanent improvements (cases, etc.),	69 50
Insurance,	45 60
Extra labor in arranging library,	25 00
Dictionary,	11 00
Total,	$1571 95
Balance in hands of Treasurer,	50 24
	$1622 19

Respectfully submitted,

A. E. Frost,
Treasurer.

Pittsburg, January 22d, 1889.

S. M. Wickersham, secretary, presented the following:

Annual Report of the Secretary of the Engineers' Society of Western Pennsylvania.

Pittsburg, January 22d, 1889.

On the 17th day of January, 1888, the number of names on our roll of members was 330. During the year there were admitted 42, aggregating 372. During the same time we lost by death 5; by resignation, 25; leaving on the rolls 342.

Ten regular meetings were held during the year.

January 17th. The eighth annual meeting; present, 50 members. Mr. T. I. Bray read a paper on "Welded Steel Tubes."

February 21st. There were present 100 members and visitors. Mr. R. McK. Loyd read a paper on "Electric Railroads."

March 20th. There were present 71 members and 4 visitors. Mr. F. C. Blake read a paper on "Electrotype Separation of Gold and Silver."

April 17th. There were present 61 members and 4 visitors. Mr. Phineas Barnes read a paper on "The Use of Aluminium Alloys in the Steel Manufacture."

May 16th. There were present 46 members. W. F. Koch read a paper on "Fifteen Years' Experience in Open-Hearth Steel."

June 19th. There were present 21 members. The evening was occupied with a discussion of Mr. Koch's paper on "Open-Hearth Steel."

September 19th. There were present 30 members. Mr. E. G. Aikman read a paper on "The Janny Coupler."

October 16th. There were present 41 members. Thomas P. Roberts read a paper on "The Railroad Situation in Pittsburg in Reference to its Approaches."

November 20th. There were present 65 members. John A. Brashear gave a talk on "Astronomical Engineering in Europe."

December 18th. There were present 39 members and visitors. J. E. Greiner's paper was read on "B. & O. Train Sheds in Pittsburg."

The ten regular meetings in the year were attended by 524 members and visitors, averaging to each meeting 52.4; being a larger attendance than in the previous year by 175 members in the aggregate, or an average of 17.5 to each meeting.

F. C. Phillips, Library Committee, reported, viz.:

MR. PRESIDENT, ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

SIR: On behalf of the Library Committee, I have to present the following report:

According to the catalogue issued in 1883 the library contained books and pamphlets, 409, periodicals 63, comprising 339 volumes. The supplementary catalogue recently prepared by the Library

Committee shows that since 1883 there have been added, books and pamphlets, 210; periodicals, 15. Of the 210 works received, 127 were Government documents, including the scientific publications of the Department of Education, Engineer Department U.S.A., the Signal Service, the 10th Census, and the publications of the Allegheny Observatory.

According to the Librarian's register the total number of visitors to the library during the year was 766, or an average of 2.3 daily. We think it may be stated that the demand has been at all times mainly for the periodical literature with which the reading-room is so well supplied.

It has been our effort to have all journals bound as soon as each volume is completed.

The drawer catalogue is finished.

A box has been placed in a conspicuous position, and a request posted that members would deposit the names of books which they recommend the Society to purchase. Two responses have so far been received. Whether this result is due to excessive modesty on the part of members, or to a lack of confidence in the liberality of the authorities, we are unable to state. Two new book-cases have been added. The importance of securing additional standard works and scientific periodicals needs no comment, and we recommend that as early as possible an appropriation be made for enlarging the library.

FRANCIS C. PHILLIPS,
Chairman.

Report of the Board of Directors ordering the names of 15 delinquent members to be stricken from the list of members was approved by a rising unanimous vote.

The Board of Directors recommended the following for membership: W. W. Shaw, A. G. Shaw, H. E. Hunt, G. H. Baxter, and H. P. De Puy, and they were balloted for and admitted as members.

Verbal reports were made from several of the special committees; after which President Dempster made the following address;

FELLOW-MEMBERS OF THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA:

Another year's transactions of our Society have been placed on record, and another annual page of its history has been written in lines of encouragement to every one interested in the progress of *our* Society.

The report of the Secretary shows a decided improvement in the attendance during the year; and the hope entertained and expressed to you one year ago has been fully realized, and much satisfaction is derived from the review and comparison of the past year with those preceding. The "Program Committee" deserves special mention and credit for the efficiency and success in having papers prepared for every meeting, and the members who have thus interested themselves in their preparation deserve the thanks of their fellow-members, and it is hoped that their example, in thus providing for the monthly entertainment, will have such influence as to prompt many more members to follow the example thus set before them. A marked improvement has been shown in the promptness that has characterized the discussions of the subjects presented in the papers, yet withal a greater degree of interest may be attained if every member of the Society would feel that he is an integral part thereof and a factor in accomplishing results, and so feeling occupy his proper place in the column of figures that constitute the value of our proceedings. You will please pardon me for urging upon all the necessity to lay aside diffidence and stiff formality, and engage in the discussions with an earnest desire to impart or elicit instruction, as such adds materially to the general interest of all.

How to increase the active working list is a matter of no small importance as an element of success in the history of our Society, and one that should receive attention. All members are theoretically on the active list, but a large number practically occupy an honorary position, and cannot be expected to contribute in papers and regular attendance. The fact that they show an interest in the welfare of the Society by the payment of dues is of itself encouraging, and should be taken as a sincere token of their good will. By a little effort amongst this class some might be trans-

ferred to the working class, very much to the benefit of the Society, as their knowledge, observation and experience would be quite an addition to the general fund of information drawn from some of the members for the benefit of all. If they could be influenced to attend the meetings I have no doubt that the Chair will educe from them something useful, interesting, and practical.

How to stir up the zeal and interest of the younger members of the Society is also a problem that presses itself upon us for solution. How to get them to apply the vigor and enthusiasm of youth and the force of brain to the lever of action, and thereby develop the mental energy that is now stored up as a latent power that will add zest to our proceedings, is well worthy of consideration; as young men are the hope of the country in Church, and State, and Forum, so are they likewise in all that pertains to the development of useful and scientific knowledge. They should be encouraged by the older to participate in all our proceedings, and be made to feel that they too are efficient factors in extending the influence and increasing the benefits of our Society both to themselves and others. I know that the greatest difficulty in the accomplishment of this lies in the fact of their own modesty and backwardness to appear as peers of older men; but this should not be. Many cases are on record where the junior has shown himself the superior of the senior, and demonstrated the advancement that has been made along the lines of knowledge, and the young man of to-day is by the superiority of his advantages fully abreast of him who has attained the seniority of years, and, as one of the "older men," I urge upon all young men to resolve and act according to ability and opportunity, and you will find all the encouragement that you desire.

How to extend the lines of the influence of our Society for good throughout our community is also deserving of candid consideration. Our Society should be as light set upon a hill, radiating its beams along the avenues of practical requirement and useful application. I fear that some of our members take too limited a view of the aim and scope of our Society, and by so doing cause others to do the same. This has been particularly manifested by the expressions of a very few individuals who became members

with the sole object in view of advancing their own individual pecuniary interests, and not having aught else to actuate them, they did not achieve the benefits they had hoped for, and consequently dwindled into the obscurity that always shadows those who have no higher motive. Man does not live for himself alone, and he whose actions are dwarfed by such narrow considerations misses the golden opportunities afforded along the avenue of life's pursuits, and fails to reach the standard of true and noble manhood. I am glad to say we have had but few of that class. It is true that there is a chord of selfishness running through the composition of every man, but there is also one of philanthropy that draws him along the lines of usefulness, not only to himself, but to his fellows; and he who can make the former secondary to the latter exhibits the highest type of manhood. And whether in social or other circles that merge in the great cycle of life's accomplishments his motive power is always applied to impel him forward in the right direction, and the wheels of action always "keep to the rails" that guide them to the highest goal of human attainment.

If each member could be fully impressed with the idea that our Society could be made a means of accomplishing a good work, not only for its members, but for the community as well, and, being so impressed, work up to the full measure of opportunity, and we should lay the lines of our action more energetically in that direction, our influence would be more felt throughout the cities of Pittsburg and Allegheny, and our Society would occupy a more prominent position in the estimation of the people, and place the premium of appreciation upon our efforts.

I do not think we should be content to radiate the knowledge and information contained in the papers and proceedings of our Society through the individual spheres of its membership, but should endeavor to supplement such instruction by others in a wider range for the benefit of the many who do not belong to our Society, but who are the hands and mechanical appliances that constitute the bone, nerve and sinew of our workshops, our mills and foundries.

Our Society could institute and conduct a course of lectures on

scientific and practical subjects, and procure able and eloquent masters who would clothe the technical abstruseness of the highest and most advanced subjects in the attractive robes of plain and instructive diction; that would prove popular and beneficial, not only to the artisan and mechanic, but to the proprietors of the different establishments in which they work. I have no doubt that there are many young men, and old too, who would be glad of the opportunity of thus improving themselves, adding to their usefulness and enhancing their chances of promotion in the lines of their specialties. History is thickly dotted with the examples of many men whose names are engraven in the niches of time, who have made themselves a name and place amongst those who have wrested from nature's arcana the legitimate fruits of labor and genius and given them to the world for the benefit of humanity, and did so by the personal application of mental power and mechanical skill after they had attained to the years of their majority; and if the biographies of many of Pittsburg's substantial and enterprising manufacturers were written to-day they would exhibit the fact in colors clear and distinct.

The matter is worthy of a fair, candid and energetic trial, and I hope that the effort will be made ere the Society is another year older. Not only would the benefits be generally diffused, but they would also contribute to the prosperity of the Society.

Another means of extending our influence, and exciting a greater degree of interest in our proceedings by those not members, would be the consideration and discussion of such subjects as would be of *general* interest. I believe it is the legitimate province of our Society to turn on whatever light we can command on any and all subjects in the line of our profession, especially those in which the public at large are interested, and from a purely professional and unbiassed standpoint extend the benefits of whatever knowledge we may possess to those who have "to foot the bills." Let me illustrate my meaning by an example that I think is worthy of imitation in all such cases. When the competing architects submitted their plans for the "Court House" the County Commissioners, with commendable forethought and in the cultivation of a desire to get the best plan that could be devised, placed the

plans on exhibition for the inspection of all, and inviting such suggestions and criticisms as any one might see proper to offer. Such did not depreciate the reputation of the architect, or lower him in the estimation of an appreciating public, but the result was rather a commendation of his merits and a fuller confidence in his ability. Whether or not he received any hints that caused him to modify his plans in any particular I do not know, but one thing is certain, his work suffered not from the criticisms passed thereon, public though they were. Of course this could not be done in all cases; but it could be done in many, very much to the advantage of the work, perhaps, and more to the satisfaction of those financially interested. I do not mean to say that we should trespass on the rights of the eminent domain, which is the special professional territory of public officers charged with such work, nor would I for a moment commend impertinent interference with the legitimate prerogative of those who hold the reins of professional control in public works of engineering, but I do mean to say that we may carry professional courtesy too far, as doctors do, who allow the patient to die rather than that they should violate the self-constituted rules of professional etiquette. I do not think we should consider ourselves guilty of an unpardonable sin if we take professional cognizance of works of engineering of a public character. No good engineer is conceited enough to think that he is the embodiment of knowledge and wisdom, and he who is the most expert in his profession is always ready to listen to friendly suggestions. Sometimes engineers in public offices are placed in an unenviable position by political gamesters, who force them into professional pawn or checkmate their best moves by the castles and knights of political legerdemain.

Of course, such might be made subject to abuse by selfish and envious men, or active, unscrupulous competitors who, actuated by impure motives, might try to embrace the opportunity to depreciate the value of the work and detract from the reputation of the engineer; but that could be easily averted, and, if tried, the rebound on the person so trying would be much more serious than upon the person on which the attempt would be made. Every work of magnitude, which is intended to be enduring for

centuries it may be, would lose none of its importance, nor would he who plans the same, lose any of his merit by eliciting the suggestions of those who would be able to give them intelligently and well. Some improvements might be made if the planner would listen to learn.

I know, if the plans of the slowly ascending pile on Fourth and Smithfield had been submitted to public inspection, and the suggestions heeded, our Chamber of Commerce would have been spared the trouble of going to Washington to have the classical faces shaved off from the arches which they disgrace, and several other betterments might be yet enjoyed by the generations yet unborn who may be present at its completion and dedication. Public works, either Municipal, State or National, which are of sufficient importance, either from a financial or professional view, as to be worthy of the best that can be educed in their line, should receive the attention of our Society, and be subjected to the ordeal of a just, fair, candid, and professional criticism and discussion. None will be hurt, and the conscientious engineer, who wants to furnish the best at his command, will not be offended at the exercise of professional criticism delivered in a professional and courteous manner.

The honorable Governor of our Commonwealth has deemed it of sufficient importance to the people to recommend the State Legislature to consider the practicability of legislating for the improvement of our highways; then why should not our Society, in the exercise of its best judgment, make suggestions to our legislators that would aid them in legislating intelligently on the subject? Where could suggestions better come from than from a society that numbers so many engineers amongst its membership.

I would recommend the appointment of a Special Committee who would be charged with the duty of suggesting a form of procedure relative to the construction and maintenance of the public highways that would inure to the public weal. Let not our Commonwealth lag in the race of progress, and let us assist to push forward the car of improvement. The subject of a uniform legislation relative to bridges has been agitated by several of the sister societies of the country, and a committee was appointed by this

Society to co-operate with them, but nothing has been yet done towards any definite action in the matter. Our "Committee on Tests" has not been *dead*, but *sleeping*, during the year, and the Special Committee on the subject of drainage or sewerage on the South Side, and of high and low water lines along our river shores, have also taken matters very easy, and no report is forthcoming from either of them. I believe it is a fact that they have not even met. I recommend to my worthy successor that he awake them to action.

As a healthy and vigorous boy outgrows his clothes, so our Society has outgrown the limits of its room accommodation for meetings, and even for the accommodation of our increasing library. And, as this is the last year of our lease of this room, the question is where and how shall we procure suitable quarters to accommodate the Society in the future. I would suggest that, as there are quite a number of societies, such as the Photographers, the Microscopic and other societies who, I understand, have not rooms sufficiently capacious to accommodate their meetings, we confer with them in reference to procuring such rooms as would be advantageous to all. One meeting hall could accommodate all, and the cost distributed amongst all would not be oppressive on either. No society would lose its own identity, but each would retain its individuality as now, and have its own special rooms, the combination being for mutual benefit financially. Other benefits would no doubt accrue by friendly intercourse. A kind of Academy of Science, if you please, could practically thus be formed, each society being a section thereof. I would recommend a committee be appointed early in the year to confer with whomsoever may be desirous of attaining that end, and project a basis for united effort which will tend to mutual benefit.

It affords me great pleasure to testify to the uniform kindness and courtesy you have always extended to the Chair during the year, which has made the duty of presiding a matter of form. The exceptionally good order preserved during the meetings is worthy of mention, and I hope that we may make great advancement during the year, and I kindly ask the continuance of the

same hearty expression of good will and model action to the Chair during the coming year as you have always manifested towards your retiring President.

A. DEMPSTER.

The election of officers being next in order, tellers were appointed, and reported the result of the balloting, viz.: President, one year, J. A. Brashear; Vice President, two years, A. E. Hunt; Directors, two years, William Metcalf, Max J. Becker; Secretary, one year, S. M. Wickersham; Treasurer, one year, A. E. Frost.

After the announcement of the election the Society adjourned.

S. M. WICKERSHAM,
Secretary.

FEBRUARY 19TH, 1889.

THE Society met at their rooms at 8 o'clock, P.M., Max J. Becker in the chair.

Directors Roberts and Metcalf and 47 members and visitors being present.

Charles E. Billen, C.E., was admitted to membership.

The consideration of Sundry Road Laws now pending in the State Legislature was referred to a special committee consisting of Thomas P. Roberts, C.E., Chairman; Charles Davis, County Engineer, A. Dempster, C.E., T. H. Johnson, C.E. and A. Kirk.

A communication from the Kansas Club of Engineers in reference to supervision of bridges was ordered filed.

A proposal for interchange of privileges between engineering societies was read from Engineers' Club of Kansas City, and referred to a committee consisting of W. L. Scaife, Chairman, A. E. Hunt, and W. S. Davison.

Prof. John W. Langley read as follows a paper on

INTERNATIONAL STANDARD OF ANALYSIS OF IRON AND STEEL.

The advance which the last few years have brought about in the application of the sciences of chemistry and mechanics to the constructive arts of metallurgy and engineering is very great; and

nothing, perhaps, more distinctly marks off the present century from those which have preceded it than the extent to which scientific knowledge and methods are applied to increase the scope and precision of manufacturing operations, or to widen the field of invention. This is a truth long since recognized, and one which is familiar to every professional man; but the counterpart of it is also true: that these improved industrial and engineering operations of the day have reacted forcibly on the sciences, demanding of their followers greater precision of results and greatly more rapid methods of working. Two branches of science have felt this stimulus with special force; they are electricity and analytical chemistry.

The electrical engineer now makes daily, as a matter of routine, measurements which were quite impossible twenty years ago. And the analytical chemist is expected to arrive at results in eight or ten hours, which, if they could have been done at all twenty years ago, would have demanded one or two weeks of labor, and even then would have been far less accurate.

No line of manufactures have made heavier demands on the professional man than those of iron and steel, including the structural applications which spring from them. Engineers now specify the quality of the metal they wish within very narrow limits, and demand that it be submitted to extremely searching tests; occasionally they also specify a particular composition, but whether they do the latter or not, for the manufacturer it is always primarily a question of composition which he must first know and next regulate with almost mathematical precision.

For instance, in some kinds of steel the carbon must be adjusted to $\pm$ 1 part in 5000 of iron; phosphorus to $\pm$ 1 part in 10,000; and sulphur to $\pm$ 1 part in 30,000, besides keeping a close watch on silicon, manganese, and one or two other elements.

Obviously, this can only be done by chemical analysis supplemented by manufacturing skill, but the analysis must be fairly accurate or the skill will be of little avail. The present condition and future improvement of the iron industries is therefore largely a matter of applied chemistry, and for purposes of illustration, this science might be called a species of telescope which en-

ables us to look into a block of ore or a lump of metal and see what is inside of it, otherwise, we are but groping in a twilight mist of old traditional practices and rules of thumb.

But this all-important aid to vision is far from perfect, and has, moreover, a fallible human eye behind it; hence, arises much practical difficulty, discrepancies of analysis, conflict of reports ending sometimes in lawsuits. The manufacturer sends material which he thinks is good and it is rejected by the purchaser, or sometimes the steel maker may let an article go out which he knows is on the shady side of the debatable line, and yet the experts of a government board may pass it with approval. These cases are of not infrequent occurrence, but it may be confidently asserted that where fraud is absent, the cause of these troubles is, ninety times out of a hundred, due to the fact that the parties to the transaction have not before them definite and authoritative standards, chemical and mechanical, of the material in dispute. The governments of the world long ago established standards of weights and length as well as of the value of coins, without which commerce and the arts would be impossible. Now, if we will think for a moment, what would be the result in the engineering and constructive arts if there was no common understanding about the value of the foot, the yard, and the metre; or the effect upon commerce if it was impossible to learn the worth of the dollar, the franc, or the pound sterling, it is pertinent to ask why the great metal trades are to-day, industrially speaking, in the condition of barbarians who do not possess anywhere an authoritative standard of the chemical composition or the mechanical properties of a single one of their products.

I will venture to repeat that statement under a slightly changed wording—There does not to-day exist anywhere in the world, a piece of metal whose physical and chemical individuality is known in the same authoritative way in which we know the length of the standard metre bar in Paris or of the standard yard in London.

The immediate and practical need of standards of composition arises from the following considerations:

The precision of analysis is now so great that it is sensibly limited by the conditions influencing two of the most important

instruments connected with it; these are the balance and the human brain.

The final weighings in analysis often deal with quantities so small that the influence of temperature becomes of great importance. The difference of temperature between that of the room and of the interior of the balance case may easily cause an apparent loss or gain in weight of a train of absorption tubes of .001 gram. It is nearly impossible to weigh such a train to within ± .0001 gram. because of the differences of temperature between the two arms of a balance if it is in a room artificially heated. Another cause of error lies in the fact that platinum crucibles condense a film of air on their surface and their weight may thus be affected by the varying hygrometric state of the atmosphere from day to day.

The human brain is subject to still more erratic influences. Astronomers have long known that two observers can rarely record an interval of time alike. One of them may note the passage of the image of a star across a wire one-tenth of a second late, another observer two-tenths late, another observer one-tenth *too soon*, and so on. This is called personal equation, and is connected with the velocity of nervous propagation and the rapidity of intellectual action. Now, chemists, too, have their personal equation; only with them it is not a matter of time-rate, but instead, takes the form of differences in the appreciation of color, or of temperature, or of odor; so that two men, working side by side and by the same method, may always obtain results which tend to differ from each other by a constant amount, this departure being due to physiological and psychical causes; in short, a chemist's personal equation.

A still more important source of variation is caused by different methods of analysis which introduce into chemistry a class of errors similar to those brought about in mechanics by the use of foot-rules, which depart from each other slightly in length. And as there is always a choice of methods, and, moreover, these processes are themselves constantly being modified with a view to their improvement, we have here a fertile source of discrepancies.

Now, considering these three classes of errors, viz., those of weighing, those which are personal to the operator, and those due to the process employed, it is remarkable that the differences of analytical reports are not greater than they are.

A practical remedy for most of these evils can be found in a system of international standards of iron or steel, whose composition shall be most rigidly and authoritatively determined by committees of chemists and metallurgists, appointed in the most important iron-producing countries. These committees propose to analyze a set of samples which shall be prepared in one place and distributed to the several countries; after the committees have made their reports, the standards thus established will probably be deposited in some public place, and small portions of them can then be issued to properly-qualified applicants. A chemist obtaining a sample of the standards can then check his own work by them, and thus he can determine a factor by which in future his results must be multiplied to make them agree with the standards. It is confidently believed that this plan, if successfully carried out, will result in a very considerable degree of uniformity in the analysis of these important metals in different countries, and will greatly lessen those scientific and commercial disputes which now sometimes assume formidable proportions.

It was my fortune this summer to submit the above ideas to some of the principal chemists and metallurgists of Europe, and to find they approved of them and were willing to give them the authority of their support. The result of personal interviews and considerable correspondence is that committees have been formed in four European countries and the United States.

These committees are as follows:

In Sweden, Professor Richard Åkerman, of the Royal School of Mines.

In Germany, the Minister of Public Works has officially assumed charge of the investigation at national expense.

In England, the British Association for the Advancement of Science has appointed a committee consisting of Professor Roberts Austen, Sir F. Abel, Professor J. W. Langley, Mr. John Spiller, Mr. Edward Riley, Mr. G. J. Snelus, Professor Tilden, and Mr.

Thomas Turner. This committee has already issued a printed circular.

In France, Monsieur Ferd. Gautier will have charge of the work.

In the United States the subject has been submitted to the American Society of Civil Engineers and to the governing board of the University of Michigan, who have appointed a joint committee consisting of Messrs. William Metcalf, Thomas Rodd, and Alfred E. Hunt, of the Society of Civil Engineers, with Professors J. W. Dangley, A. B. Prescott, and M. E. Cooley, of the University of Michigan.

The plan, as agreed on thus far by the committees of the several countries, proposes that from 150 to 300 kilos of steel, representing as nearly as possible 1.3, 0.8, 0.4, and 0.15 per cent. of total carbon respectively be prepared in five lots. After the ingots are cast, the outer skin is to be removed and then the metal cut into fine shavings, which shall then be crushed, sieved, and intimately mixed. These shavings shall then be hermetically sealed, and an equal portion of each sample sent to each of the five countries above named, where they will be independently analyzed. When the reports are completed they will be interchanged, and the average of all will then be deemed the true and authoritative composition of the international standard.

To the writer of this paper has been assigned the duty of preparing these samples, a task which would have been quite impossible except for the great interest which Messrs. Miller, Metcalf, and Parkin have shown in furthering the cause of metallurgy, and the practical side of chemical analysis. To their co-operation is due the fact that the preparation of the samples is now well under way at the Crescent Steel Works.

In conclusion, the writer begs to say, that the establishment of a set of international standards is a matter which appeals not to chemists only, but to every engineer and iron and steel worker in the land; he therefore ventures to hope for the co-operation of this Society in the work by their advice and suggestions as to the best methods of dividing the metal to secure absolute uniformity, and also that some of the chemists of its membership may be willing to take, as a labor of love for science, some part of the very large amount of analytical work called for.

Discussion of Paper.

J. W. Langley: And I may add as a supplement to the paper a few portions of the circular which the English Committee have issued, copies of which were received in this country a short time ago. After giving a list of the Committee it goes on:

It is proposed that the Committee shall co-operate with other similar Committees in the careful testing of specimens of iron and steel, the chemical composition of which shall have been carefully determined. The specimens adopted as standard shall be so considered and the same recognized as authority and shall be used thereafter.

H. D. Hibbard: I would like to ask the size of the ingots in which this sample is cast?

J. W. Langley: The ingots which have already been prepared are $3\frac{1}{2}$ or 4 inches square and about 36 inches in length. They are then mounted in a lathe and turned up.

H. D. Hibbard: Is the metal thus prepared to insure all the ingots to be the same in uniformity as if mixed in a ladle?

J. W. Langley: No; that is not necessary. One ingot of each of the standard carbons shall be prepared; the weight being 90 pounds per ingot.

H. D. Hibbard: I thought the ingot would possibly be larger, but the small ingot does away with the objection I thought of; that is, the segregation always found in the large ingot. I have found difficulty in this respect, in preparing standards for color-carbon determinations. After selecting a piece suitable otherwise, I found it necessary to take drillings from numerous different places in the bar for comparison with each other to ensure reasonable uniformity in the standard. That was always in steel cast in ingots larger than 4 inches square.

W. Metcalf: In regard to that matter of uniformity, there is little want of it in the small ingot. There may be some segregation, but I noticed from the paper that it is proposed after the ingots are cut into the very fine shavings they are pulverized, then sifted and mixed, and incorporated through one another so

that the final result of this extremely fine powder of steel must be practically uniform.

H. D. HIBBARD: How fine is that?

W. METCALF: He speaks of 1–16 mesh, but a good deal will be finer than that. It is thoroughly mixed up, and this removes the objections to the segregation in the larger ingot.

F. C. PHILLIPS: As to the benefit of this measure, it seems to me that no criticism is necessary. It is a most admirable move, and it is strange that something of the kind has never been attempted before.

It seems to me, however, there is one difficulty in this matter. I understand Prof. Langley to say that the quantity is very limited; that the steel works' owner will be fortunate if he succeeds in getting an allotment of 10 grammes. Now, as the bar is standard, and as it is probable that a number of determinations will be needed for each cast of metal, it would seem rather unfortunate that larger quantities cannot be provided. Of course, the difficulty of getting homogeneous metals will stand largely in the way of that, but it is to be wished that the Committee who have this matter in charge can arrange in some way so as to allow of comparisons being made in larger quantities. I do not know whether that can be done. As to the plan the measure proposed might be extended to a great many other things besides iron and steel with great advantage. I hope to see it carried through, and that our Society ought to give its full endorsement, as I have no doubt it will.

W. E. KOCH: I do not think there is much difficulty in keeping a standard if you once find it. In the early days of steel making we had a standard. Unfortunately, we only started in with a small bar, and we ran out of the standard, but soon recovered it by making comparisons with other bars, and we kept the same standard, although the bars were used up two or three times.

But I think the Committee will do us a good turn if they will define what steel is. I had some stuff sent me the other day called steel, and when I came to analyze it I found it had about 3–10 silicon, 1–10 phosphorus, 9–10 manganese, .35 carbon, besides traces of other ingredients.

H. D. HIBBARD: It has been my experience that it is better to have the pieces sifted as near one size as possible; that is, in the sifting the pieces should be no larger than a certain size, and no smaller, because it will be found that the finer parts will be a little different in their composition from the coarser parts, so if in these analyses the mixture is made half fine and half coarse, there would be a little difference in their results.

F. C. PHILLIPS: I agree with the last speaker on that point. I think it would be necessary that the parts be of the same size.

T. P. ROBERTS: I am not very much of a chemist but I think I can appreciate the point made by these gentlemen, and it will suggest this idea. We see in breaking coal that the finer parts retain much the greater proportion of sulphur. In coal mines, in taking out the coal, the finer parts seem to give off the refuse, and this is natural, because I think it is on the line of the sulphur that the coal will break. It occurs to me, therefore, that specimens of such comminuted metals may vary very greatly and be to each other in proportion to their relative fineness.

J. W. LANGLEY: I will take a moment to reply to one or two of the suggestions made. One in regard to the necessity of taking the difference between two screenings. This will be watched.

It is very unfortunate that large quantities of the steel cannot very well be prepared, but only a practical steel maker can have any idea of the large quantities of material which have to be dealt with to get the 90 parts thoroughly homogeneous. Indeed, the four ingots already prepared represent not less than 5 to 10 tons of steel, and if we attempt to get a double set of these four ingots, it would represent more like 1000 tons of steel, as the difficulty would increase something like a square of the number; therefore, the quantity of standard authority must be somewhat small.

Probably the remedy would be to make the allotment of samples limited to those who are specially interested in such manufactures, and a few given to the chemists who can multiply copies in the same way as our weights and measures that are to be found in every grocery store. Only one copy of the standard of weight

is in this country—that in Washington—and in the course of time it may be possible to perpetuate them on a large scale.

T. P. ROBERTS: I would like to ask in regard to these borings: do you use oil or water?

J. W. LANGLEY; No; they are perfectly dry.

A MEMBER: There must be a considerable heat developed.

J. W. LANGLEY: Yes; a great heat.

T. P. ROBERTS: Do you think any part of the tools may grind off and get into the borings?

J. W. LANGLEY: There must be; but only a very minute quantity.

T. M. HOPKE: Will the various chemists who make these analyses be expected in their reports to give the method used?

J. W. LANGLEY: Certainly.

H. D. Hibbard read the following paper exhibiting, also, many specimens of various metals welded by the process described.

THOMSON ELECTRIC WELDING PROCESS.

This has attracted considerable notice in scientific papers for the past year because of its scientific valne, but now it is assuming its proper position of usefulness in the world. To this end a company has been formed which controls and is introducing it, named the Thomson Electric Welding Co.

It is the especial pride of the inventor, Prof. Elihu Thomson, and I was told that he claims more originality in this line than in the other applications of electricity with which he has had such great success.

Results are obtained hitherto deemed impossible. Brass, copper, lead, tin, zinc, German silver, bronze, silver, gold, platinum, steel, wrought-iron and cast-iron are welded together and in various combination, one with another.

For a list of the actual and proposed uses I refer you to their pamphlet.

The fundamental principle involved is not new. It is that resistance to an electric current transforms a part of the energy into heat, but the application to this purpose is novel and promises to find a large field for work.

The principle is applied by causing the ends of the pieces to be welded to form the poles of an electric current of proper strength. The pieces are held in suitable heavy copper clamps, one of which is insulated from the frame of the machine by thin mica plates, the bolts which hold it being insulated by means of mica ferrules and washers. The current used is of very low potential, from 1 to 2 volts, so that insulation is easily effected. The quantity of electricity is very great, running into thousands of amperes, this varying, of course, with the size of the pieces worked upon about as the area of the section. There is no danger to life in using such a current as it will not pass through the human body.

One of the jaws or clamps which hold the work can be moved towards the other by turning a screw so that the pieces may be forced together when properly heated.

The writer and a friend recently visited the office and works of the Company, saw the process in operation and obtained a few specimens, which are here shown. At the office in Boston are many samples of the work done, including most of the metals named above. The largest piece shown which had been welded was a 2-inch round iron bar. After inspection of these, the train was taken for Lynn, where the works of the Company are situated.

The shop itself, equipped for the manufacture of the machines, does not require description. They have machines, however, ready to illustrate the process, and two welds were made in our presence, one of which, the larger, I was kindly permitted to take away. It was this $1\frac{1}{4}$-inch round iron bar, which has since been split through the weld, and one-half etched with acid developing its structure. The weld is apparently perfect. The pieces had been dressed, that is, slightly rounded on the ends and placed in the machine before we reached the works. The actual time the current was passing was, I estimated without actually timing, from twenty to thirty seconds, the heat gradually rising to a beautiful welding heat, the pieces being forced together at the time, producing the upsetting you observe. Two pinches of flux, dehydrated borax, I think, were used on this weld. The work required about 30-horse-power.

The other weld we saw made was of half-inch rounds of soft

steel. A few seconds only were required to make the weld after the pieces were in the machine.

I have said that the ends to be welded formed the poles of the circuit. This is not strictly true, as the pieces are touching when the current is started, but the contact is so imperfect that the great resistance is at that point.

The heat was sufficient to have admitted dressing down the weld on an anvil if quickly done but the heat is so localized at the weld that the temperature falls quickly because of the conduction of heat to the cold adjacent parts of the bar.

In one of his patents Prof. Thomson describes an arrangement for hammering the weld while in the machine, and the heat is kept up by the electric current. Though the welded part is as large or larger than the rest of the bar, its high temperature makes it the point of greatest resistance, and therefore of greatest conversion of electric energy into heat. So the temperature is maintained as long as the current passes. Welds may also be dressed cold with machine tools with satisfactory results.

The absence of foreign matter such as might get into the joint from a coal fire makes these welds peculiarly reliable. Numerous tests pulled in a machine show the welds of the same metal to be practically of the same strength as the rest of the bar. Welds of unlike metals are, however, likely to give way at the weld.

The Company does not propose to do welding itself commercially, but to furnish machines to its customers on suitable terms. The only machines sent out so far have been to wire works. Copper wire welded as the samples you see here, are drawn down through successive passes, the welds being indistinguishable from the rest of the wire. The weld is an ideal one.

Chains made with two welds in each link somewhat upset are stronger at the weld than elsewhere, and the upsetting serves to prevent them kinking.

Rings closed with a single weld are also made by this process. The current largely seeks the short circuit through the joint in preference to going around the ring, heating it and enabling the joint to be made.

Welding pipes of iron, steel, brass, and lead is another very

useful application of this process. Lead and brass which are joined by fusing the abutting ends join very smoothly. Iron and steel merely becoming soft are upset in the machine and flared out so that there is an enlargement of the bore just at the weld.

A machine was in the shop just completed for brazing bicycle yokes. Of course, the degree of heat needed is far below that of welding, but it is under good control and the proper amount can be applied.

For each different purpose a special machine must be contrived to give the proper shaped clamps and other proportions suited to the work.

This small bar formed of sections of iron, German silver, brass and copper, welded together in that order illustrates some of the possibilities of the process.

In view of the limitations which have been put on the meaning of the term "weld" by members of this Society, perhaps some other word should be invented to describe the results obtained by this process. The joining includes all steps from sticking together when pasty to actual fusion of the parts united.

Discussion of Mr. Hibbard's Paper on Welding by Electricity.

Prof. Langley: I might add one bit of testimony to the facts stated in the paper. I had the pleasure last summer of seeing aluminium welded by this process—2 $\frac{1}{2}$-inch rods perfectly welded together in about 30 seconds.

W. E. Koch: In 1881, I think it was, the late Sir W. Siemens had a 20 horse-power engine and dynamos, and made some electrical welding experiments. We found with such welds that when we pulled them it was all right. We would take a bar, for instance, weld it in that manner, and if it was pulled the weld was all right, but if we gave it a smart knock over an anvil with a hammer it would drop off just below the weld, and I would like to know if these parties Mr. Hibbard speaks of have had the same trouble. The break showed a crystalline fracture.

H. D. Hibbard: I do not know whether they had any such trouble or not.

W. E. Koch: The process was abandoned probably on account of this trouble. I have never been able to find anything about it, but it may be by using a low carbon steel it might give a different result.

Wm. Metcalf: Did you ever try heating these bars and forging down to the size of the weld?

W. E. Koch: That was all right when we took and forged them. They came all right.

T. P. Roberts: I think, Mr. President, the trouble Mr. Koch complains of must originate with the rapid absorption of heat, for in the paper it spoke of the bar being quickly brought up to the welding-point, and that it cooled rapidly. I suggest the idea that there was a diffusion of heat in some way; the movement of the particles on the line where that fracture was, developed the crystalline structure. If that bar had been heated immediately afterward and left to cool gradually it might have relieved that difficulty.

H. D. Hibbard: It looks to me from Mr. Koch's admission that it was solely a question of heat without work, which we know is injurious. The steel or iron there heated was over-heated, without any work being done. Of course, a blacksmith who hammers every part of the bar forging down to the weld removes the difficulty.

Wm. Metcalf: I think it was altogether heat without work. Changes in the temperature will affect the grain both in steel and in iron. If you take two bars of steel and stick them together, and bring them up to a welding-heat in a very small length of the bar, it is absolutely certain that there will be a difference in the steel for that portion, from that portion away from the weld, or in other parts of the bar. The fact that the steel has been brought to a very high heat, and that it has cooled very rapidly, shows that this change in the grain must have been in the neighborhood of the weld, and that sudden change in temperature would certainly make any piece of steel brittle, more or less, according to the quantity of carbon. And it would naturally break off at the point Mr. Koch said it did break.

It was for that reason I asked if he had tried a specimen weld

by afterwards hammering it down, for the putting on of so much mechanical work at a lower heat, would bring the grain back to the condition it was in in the original bar, and I think that Mr. Koch's experience will be repeated by everybody who makes an electrical weld of that kind, unless he uses some means to remove the difference in the grain, and the strain in the steel produced by it. That is about the simple explanation of it.

G. LINDENTHAL: I would like to ask if Mr. Hibbard thinks that if hard wire, after being welded together and worked in the way Mr. Metcalf suggested, that the weld will be as strong as the wire, or only give the strength of the original steel.

H. D. HIBBARD: I think the strength of the weld would be no more than that of the wire heated by any other means. The increase in strength due to drawing would be removed by the heating.

G. LINDENTHAL: Would it have the same strength as the rest of the wire?

W. METCALF: I will say, in answer to Mr. Lindenthal, that if I had to build a wire bridge I certainly would not weld the wire.

G. LINDENTHAL: Ever since I have known anything about the subject of eye-bars, which were made years ago by welding on the heads, I never questioned that the weld can be made good, but I question very much whether every weld is good. And in the matter of wire, I would certainly be very loath to weld it together, and consider it as good in the weld as in any other part.

H. D. HIBBARD: For this class of work probably another system of electric welding in which the piece of work forms one pole of the circuit, the other being a carbon-point would be better suited. By this, local heating and welding of any portion of the work may be accomplished.

The Society adjourned at 9.45 o'clock, P.M.

S. M. WICKERSHAM,
Secretary.

MARCH 19TH, 1889.

SOCIETY met at their rooms at 8 o'clock P.M.

President J. A. Brashear in the chair.

Vice-Presidents, W. L. Scaife and A. E. Hunt.

Directors, T. P. Roberts and Chas. Davis; and thirty-five members and visitors being present.

Messrs. Lewis S. Clarke, Robert A. McKean and A. C. Kerr were duly elected to membership. W. L. Scaife, made the following report from the Committee on Interchange of Privileges:

Gentlemen: Your Committee appointed to consider the plan of arranging the transfer of members from one local society to another, suggested by the Engineers' Club of Kansas City, beg leave to submit the following report:

Whether we consider the matter as one of individual interest and profit, or of public policy, the proposal to open the doors of the different societies throughout the country to the members of any one of them, cannot fail to meet with general approval. There is room, however, for difference of opinion as to the best means of accomplishing this object.

Your Committee would suggest the following method as one of several that might be adopted.

Suppose that the Engineers' Societies of Kansas City, St. Louis and Pittsburg, had agreed upon the proposed plan, and that one of our members, Mr. A. B., desired to settle in Kansas City for a time, and to join the Engineers' Club of that place. Mr. A. B., would make application for a card to our Secretary, paying the latter one dollar to cover expenses and prevent useless applications. The Secretary would give Mr. A. B. a card, stating that he was a member of this Society, and that he had paid all dues to the end of the year. On presentation of this card to the Secretary of the Kansas City Club, the latter would place his name among the list of members, with all the privileges of the Club except voting and printed *Transactions*. At the end of the year, if Mr. A. B. still remained in Kansas City, he could be admitted to full membership in that Club, with privilege of voting and *Transactions*, on compliance with their rules governing the election of members.

Should Mr. A. B., decide to move from Kansas City to St. Louis, he would receive from the Secretary of the former Club, a card stating that Mr. A. B. was a member of the Pittsburg Society, transferred to Kansas City, or a member of the latter Club alone, if he had been formally elected, and that his dues were paid to the end of the year.

On presentation of this card to the Secretary of the St. Louis Society, Mr. A. B. would be received just as he had been in Kansas City. He would, of course, be subject to all the rules of each Society, while connected with it, except the payment of dues and assessments, to the end of the year in which his card was issued.

He should receive printed *Transactions* only from the societies to which he had paid all dues covering the period during which he desired to obtain them. Respectfully submitted,

W. L. Scaife,
Geo. S. Davison,
Alfred E. Hunt.

On motion, it was ordered that a copy be sent to the Kansas City Club, with the assurance that this Society is ready to name a committee to act with a joint committee for arranging a scheme for final action among the various engineering societies.

Thos. H. Johnson, from the Committee on Roads, read the following report:

Your Committee begs leave to report, that, during the month since we were appointed by the Society, to examine and report upon proposed laws, to be acted upon by the Legislature of Pennsylvania, affecting the highways of the various counties, we have had a number of meetings, and although the time has been short for the collection of papers and documents bearing upon the subject, we have deemed it best to present for consideration of the Society, a draft of a bill, which, if favorably acted upon, we recommend be immediately forwarded to Harrisburg.

Numerous bills have already been formulated by members of the Legislature and are now in the hands of the appropriate committees; but if our Society is permitted to hope that any of its

suggestions are to form a part of the State laws, it is important that immediate action be taken, for it is thought the Legislature may adjourn about April 25th.

The draft of the bill submitted by your Committee speaks for itself, and if it can be improved upon, by suggestions made in this meeting of the general Society, the Committee will be glad to have its errors or omissions pointed out.

The subject committed to us is one of great and peculiar interest, not only to the State of Pennsylvania, but we may say of national interest. It is of interest, not only to civil engineers, but to all classes of citizens. Engineers, however, are perhaps, in some respects, better qualified by reason of their large personal knowledge of the topography of the State, and its means of communication, to discuss the practical benefits of, and the urgent necessity for, improved roadways in the country districts, than are other classes, whose duties do not require them to travel afoot frequently, and to great distances from their homes. That there is a peculiar propriety, therefore, in engineers discussing the road problem, there can be no doubt. Of one thing we are sure, viz.: that if engineers had been called upon to lay out, construct and supervise the maintenance of the roads in the Eastern States, during the last forty years, a vastly different picture would be found from what appears to-day.

Most of the counties of Pennsylvania have come to a complete standstill, so far as increase in population and value of natural products are concerned. The tide of immigration from Europe passes unceasingly through her territory without stopping; although the proportion of unbroken or forest land in Pennsylvania to cultivated land is still very large. By the census of 1880, it is shown that in Pennsylvania the percentage of forest to total area was 24.3. Of the remaining 76 per cent. nearly one-half is non-cultivated or waste land. In New York, the per cent. of forest to total area was 26.2; in Maryland 31.7, and in New Jersey as much as 48.8. It is therefore a fact, that these States, which embrace the chief commercial and manufacturing cities of the Union, and the densest population, considering their combined

area, have a greater proportion of unbroken ground, than other regions of the same size in the more sparsely populated regions of the West. Here, then, there is room for many thousands of settlers. The farming lands of these States are only valuable on the narrow strips bounded by a few miles width, through which the railroads pass.

The hue and cry has gone forth that Pennsylvania farmers cannot compete with the wheat raisers of Minnesota and Dakota, because of some mysterious evil that the railroads have done them. There are, no doubt, causes of complaint by the eastern farmers of the railway administration, but sifted down, most of the troubles which afflict the Pennsylvania agriculturists originate in their inefficient means of reaching the markets.

To the farmer, the market simply means the nearest railway station. If he be located ten miles distant from the railway, the character of the roads often requires a whole day's labor with a team of horses to transport 600 or 700 lbs. of produce to the station. It never occurs to those who lay out and construct these roads, what a loss this extravagant use of horse-power involves. Land at the railroad may be worth $100 per acre; while the same kind of soil ten miles distant may not be worth more than one-third of such an amount. If he could traverse the ten miles in less time and with three times the load, the farmer could market his produce with one-third the number of trips; and the time and expenditure of power lost on the road, would go to the betterment of his farm. He would live better, have more comforts, and be able to have better schools for the education of his children.

Good roads mean another thing to the farmer, an improved breed of horses. If the farmers' sons have good horses, and good roads to exercise them on, they will form an attachment for the country, which no allurement of the city can detract from. As it is, however, the farmers' sons grow restless with the plodding ways of their fathers, and seek opportunity to emigrate. It is no wonder, for what is the use of schools and education, except to advance ideas of comfort and happiness; and there can certainly be no general happiness in a district where the roads are so bad

that for months at a time people can see nothing of their neighbors?

The salient points of the law which your Committee would like to see enacted, should provide for three things being done, in connection with the roads.

1st. As to their location. It is too often the case that great detours are made by the township roads to avoid cutting the farm of some influential citizen in two. It is regarded as a terrible affliction by them to have to open two gates to reach a field with a mowing machine, where one would do. The property, it is also claimed, will not divide up so well when the farmer is dead. For these and similar reasons all the other farmers and the travelling public must forever pay a tax in the form of lost time and wasted horse-power for every load hauled around his premises. There are many thousands of these "toll gates" on the 90,000 miles of roads in this State. The very farmer who maintains one such taxing station on his property and thinks he has gained a point, loses, in going to market, more than he has gained, by paying similar tolls to others equally favored?

Our roads are susceptible of great improvement in their location. Instead of 90,000 miles, there might be several thousand miles less. That is to say, the kinks and bends which could be removed from them would reduce their length by some such figure, with corresponding reduction in the annual cost of maintenance and in the number of miles annually travelled by vehicles of all kinds.

But besides the horizontal kinks and bends here referred to, there are hills or vertical bends to be eliminated in the proper location of the roads. Farmers do not appear to regard steep grades on their roads as a very serious evil. If they could see inside of their horses' stomachs, or feel the animal's heart beat on an up grade, something in the manner of the locomotive engineer looking into the firebox of his engine, he would learn that the two machines are identically alike in consuming more material on an up grade than on a level. A pound of coal has a known and fixed value in evaporating water in the creation of steam. "Low grades" means a saving of steam and hence economy in the use of coal.

So, also, in the animal "engine" a pound of oats or a pound of hay is capable of developing a certain number of heat units, which may be displayed in energy, *i.e.*, power. In fact a horse is a far more perfect machine than any engine which can possibly be constructed, but while more perfect is much more liable to injury when overtaxed. If time permitted, it would be an easy task to prove that the State could afford to spend millions of dollars annually in improving its roads to save this unnecessary waste of horse-power, to say nothing of the positive benefit to the health, strength, and breed, which would accrue to the animals themselves by the construction of such roads.

The second point to which legislative attention is requested, is the construction of the roads. It should be the aim of the law to encourage the construction of well-drained, macadamized, or gravelled roads. On this point it is scarcely worth while to discuss the engineering points involved. They are, for the main part, simple enough, though no one plan may be applicable to all portions of the State. When we speak of macadamizing the roads we do not urge the construction of too many at one time. Certain main roads, however, we believe should be designated for improvement first; and the worst parts of these to be undertaken first. This leads to the consideration of the

Classification of Roads.

Your Committee believes there are prominent roads in every county, connecting important towns, which should be first radically improved. Now it often happens that such a main highway may traverse a very poor township, or be for miles near one end of a township to which it confers but little benefit. Hence the propriety of taxing the larger community, the boroughs, and in fact the county, for certain classes of its roads. The boroughs and cities are just as much interested in having good roads leading from them, as are the farmers who use them. This we believe is a self-evident truth; nevertheless, it is not the law in this State to permit the cities and boroughs to help pay for good roads.

There can be no doubt that if the roads from the country were always passable, the supply of butter and eggs, to meet the demands of our cities and towns would come altogether from the districts adjoining the local markets. Hay is often worth five and six dollars a ton more in the Pittsburg market than it is on farms within eight and ten miles distance; owing altogether to the fact of the bad roads, which are thus responsible for entailing a double loss—a loss to the city purchaser and a loss to the producer. To the bad roads of the country we must attribute the famines and gluts in certain commodities.

We are therefore confronted with the question, shall our main country highways be improved with funds obtained from a county tax, and built under county supervision, or shall they remain, as heretofore, under laws affecting townships only?

A second class of roads more especially useful to the citizens of a local rural district, which might be termed township-roads, may continue to be constructed and maintained under township control, so far, at least, as to the amount of money to be expended upon them. We have faith in the notion that when the advantage which will accrue to the people by improved county roads is seen and appreciated, the cross-roads will likewise be improved in a good substantial manner.

The third point which we think should be cared for in the contemplated legislation, concerns the maintenance of the roads after completion. We think it can be easily shown that for the average amount of travel which the proposed macadamized roads will be called upon to bear, that the cost of their maintenance will be less of a tax upon the community than is now borne annually in so-called "road-repairs." It, however, would be taking but a narrow view of the case to assume that this is the chief advantage of having good roads, viz., to keep down taxes for renewal and repairs. Indeed, it is not promised that good roads will lower taxes in general. Increase of taxation in some shape seems inevitably to keep pace with every march towards improvement. But, very fortunately, with the march of improvement come new sources of revenue, which more than compensates for the increase

of taxation. At all events, it is certain we cannot have good roads without paying for them. This leads us to consider

The Economic Value of Good Roads.

There was a time when all the commerce and travel of this State was carried by horse-power over the public highways. The volume of traffic thus carried was such as to make toll turnpikes remunerative and attract private capital to such investments. But when the Conestoga wagon and the Concord coach became things of the past the conditions changed. No new turnpikes were built and the old ones were allowed to fall into decay, many being abandoned by their owners and turned over to the township authorities to be maintained in the same slip-shod way as other public highways. Since that time the growth of the commonwealth has been rapid and continuous, until now the annual products of the State, which must be hauled over the public roads, has reached a volume much greater than that which made toll-roads profitable in former times, though the distances to be traversed are much less. Then the tonnage was small, but the hauls were long; now the tonnage is large, but the hauls are short.

The difference in cost of hauling that tonnage over good roads and over bad or indifferent roads is an actual expense which the community encounters continuously without fully appreciating its magnitude, but which is a legitimate subject of inquiry. From Morin's experiments, made many years ago, and which are still recognized as the highest authority on the subject, the following table has been prepared, showing the average loads which each horse can draw over different kinds of road-surface, and on grades rising 10 feet per 100, 5 feet per 100 and on the level:

Kind of Road.	Grade.		
	10 Per Cent.	5 Per Cent.	Level.
	lbs.	lbs.	lbs.
Street pavement, dry and clean	1,090	1,920	8,300
Street pavement, muddy	1,040	1,800	6,250
Macadamized Road.			
Best condition, dry, clean and smooth	1,060	1,840	6,700
Good condition, moist or with a little dust	1,000	1,660	4,700
Bad condition, ruts and muddy	890	1,390	3.000
Very bad condition, deep ruts and stiff mud	740	1,040	1,840
Clay Road.			
Best condition	930	1,500	3,600
Average condition	660	900	1,400
Newly worked, not muddy	600	780	1,100

The legal grade of 5° = 8.85 per 100, and load of one horse on that grade would be, respectively, 1150, 1090 and 700 pounds for pavement, macadam and clay roads, each in good average condition.

From this it will be observed that as the steepness of the grade increases, the efficiency both of the horse and of the road-surface diminishes; that is to say, the more the horse's energy is expended in overcoming gravity, the less remains to overcome surface-resistance. For *average* conditions of each class of road, the loads hauled are in the following proportions, taking that of the clay road as 1:

	Macadam.	Pavement.
On level,	2.75	4.46
On 5 per cent. grade,	1.70	2.00
On 10 per cent. grade,	1.43	1.58
On legal grade 5°,	1.56	1.64

The last census report gives the total quantities of the agricultural products of the State in 1879. Converting those quantites into equivalent weights (omitting orchard and garden products, which are given only in value and not in quantity), it appears that the total farm products amounted to 6,500,000 tons. Of this amount about one-half is consumed upon the farm, and the other half, or 3,250,000 tons, must be hauled by wagon for dis-

tances varying from one-half to ten, twelve or more miles. The average haul is probably not less than five miles.

We will assume that the haul is five miles, and that two loads per day are made by a two-horse team at a cost of $2.50 per day. The cost of moving the total market crops will be as follows, both in average condition and with legal grades:

	Clay Road.	Macadam.
Load for two horses, . .	1400 lbs.	2180 lbs.
No. loads for 3,250,000 tons,	4,643,000	2,981,000
Cost $1.25 per load, . .	$5,703,750	$3,726,250
Difference, . . .	$1,977,500	

This is the excess cost annually entailed upon the farm products by clay roads, as compared with turnpikes. It is enough to keep 30,000 miles of turnpike in repair, at an annual expenditure of $66 per mile.

Looked at in another way, the figures given above represent 2,321,500 days' work for a man and two horses on clay roads, as against 1,490,000 days on improved roads, a loss of 831,000 days' labor, which might have been devoted to other useful purposes.

Besides the farm products, there is quite a large tonnage of other materials, such as merchandise, machinery, coal, manufactured articles of all kinds, including farming implements, etc., which must be carried to towns not reached by railroad, or to the homes of the people in the country districts. We have at hand no data from which to estimate the amount of this tonnage, but it must be large, and will swell the aggregate loss to the general community to nearly double the sum already estimated, or, say, $4,000,000.

Mr. Andrew Carnegie, in speaking of his recent coaching trip in England, describes the roads of that country as being everywhere improved in the most complete manner, and forming a network which covers the whole country, and whose ramifications extend into the minor as well as important districts, and that these roads are maintained in a condition of the highest excellence, even exceeding those of Central Park in New York.

This description of the roads of England is confirmed by accounts from other sources. Mr. W. H. Wheeler, M. Inst. C. E., writing in the *Sanitary Engineer*, for 1887 (page 97), estimates that the saving to the people of England, by reason of the excellence of their roads, amounts to $100,000,000 yearly, in cost of transportation alone. This estimate is based not on a comparison between turnpike and clay roads, but between well-kept and neglected turnpikes, three horses on the former being rated equal to four horses on the latter. The rate which we find from the foregoing table for comparison of turnpikes with clay roads would make two horses on a turnpike equal to three on a clay road. At this rate, Mr. Wheeler's figures would become $150,000,000, an amount beside which our own estimate for the State of Pennsylvania sinks into insignificance.

In 1835 France had 45,000 miles of roads in bad condition. An eminent French engineer of that time, writing in advocacy of better methods than were then in vogue, estimated that hauling the commerce of the country over these roads cost $90,000,000, of which one-third, or $30,000,000, would be saved by putting the roads in good order. Since then, these roads have been put and maintained in a condition of the highest excellence.

The following data in relation to French roads is taken from the *Engineering News* of the current year. The roads are divided into National, Departmental, Military and Country cross-roads. The National roads are maintained entirely at the expense of the public treasury. The departments provide for the second class of roads and also partly for the military roads; and the local cross-roads are maintained by the communes, or, when of higher importance, by the departments.

In 1873, there were 223 national roads, aggregating 23,180 miles in length, of which 1632 miles were paved like a street. These roads average in width 52 feet 6 inches, or 16 m., of which 19.68 feet are for the causeway, 19.68 feet for the sideways and 13.12 feet for the ditches and embankments. The department roads are not quite so wide, the average width being 38 feet. In 1872, the aggregate length of the latter was 29,167 miles. The 28 military roads are about 932 miles long in all, and are chiefly

in the west of France, laid out after the last insurrection of Vendee. The sum of about $6,800,000 is yearly expended in making new roads or repairing old ones. The cross-roads are managed by a special bureau under the Minister of the Interior, which employs 3000 inspectors and 42,000 workmen specially charged with the duty of keeping these roads in repair. In 1872, these cross-roads aggregated 338,273 miles in length.

The Government grants yearly $1,150,000 towards the extension and repair of these roads; the balance of funds required is furnished by the communes. The commune is the administrative unit of France. France has an area of 204,091 square miles, or is 4.436 times larger than Pennsylvania.

It would be difficult to estimate how large a factor these roads have been in building up that financial prosperity which enabled France to pay "ten milliards" to Germany without bankruptcy.

But the diminished cost of hauling is not the only return which a community derives from good roads. At certain seasons of the year the clay soil of this State becomes impracticable for loaded vehicles. As a result of this, the crops must be marketed when the roads will permit, and this in turn produces a glutted market with prices at the lowest ebb. Perhaps a few days or weeks later, a change in the weather breaks up the roads, and the honest farmer is compelled to sit at home with folded hands, while the prices of his products go steadily higher and higher.

With good roads this is all changed. The market is always accessible, and prices are not sent away down because everyone can get there, nor away up because no one can. One active cause of fluctuation is eliminated, and the range of fluctuation is reduced to narrower limits. With bad roads the great bulk of farm products are sold at the *lowest* prices; with good roads, at *average* prices, while to each individual is opened the possibility, by the exercise of sound discretion, of reaching the market when at its highest.

The amount of good hard cash which the farmers of Pennsylvania lose every year in this way is difficult to estimate, but it must be enormous. Take the single item of a hay crop, which in the census year amounted to 2,811,517 tons. Of this the greater part (say two-thirds) was consumed by the farm stock, and the

remainder (940,000 tons) was hauled to market. For purpose of illustration we will assume that the price of hay has ranged between $10 and $15, and that owing to the condition of the roads 800,000 tons had been sold at the lesser price, and 140,000 tons only obtained the higher price. The total sum then realized by the producers would be $10,000,000, or an average all around of $10.74 per ton. But with good roads the supply would have been more evenly regulated to the demand; the lowest price would not have been so low nor the highest price so high, and there would have been less difference in the quantities sold at the extreme prices. To carry out this illustration, suppose that 500,000 tons had been sold at $11 and 440,000 tons at $14. The total result would then be $11,660,000, or $12.36 per ton. The gain to the producers being in that case $1,560,000, or quite a snug sum lost on a single item of farm product.

While these figures are not based on actual data, they are not beyond the range of possibility, and serve to show that the actual cash loss sustained by the farmers of the State, through bad roads, probably amounts to several millions of dollars every year. To estimate this at $6,000,000 would certainly be much too low, and yet $6,000,000 is 6 per cent. interest on $100,000,000 of invested capital.

Returns for investments of this kind are had also through another channel. It is found as a direct result of the construction of good roads, that property is enhanced in value. Farming lands situated on or near the line of a good turnpike always find the most ready sale, at prices ranging from 25 to 50 per cent. higher than equally good lands, similarly situated, but not accessible by turnpike.

This fact shows that our preceding estimates of the losses by bad roads are much too small. Building a turnpike does not make the adjoining lands produce larger crops. It enables these crops to be marketed at better prices and less cost. If, then, a farmer finds that he can afford to pay 50 per cent. more for farms which have turnpike outlet to market, it is because on account of the cheapened cost of hauling and better command of the market he is able to add more than 50 per cent. to the income derived from the farm.

In those portions of Ohio which have taken advantage of the statutes provided, 50 per cent. increased value is not uncommon, and 25 per cent. is the least estimate placed upon such difference of location. Moreover, the people of those sections would not be deprived of their good roads at any price; nor would they consent under any circumstances to go back to the old system of mud roads. They pay their road tax in cash cheerfully, and without any longing for the annual picnic, commonly called "working the roads," which they formerly regarded as an inestimable right, and a glorious holiday, second only to the Fourth of July and Christmas.

Mr. Satterthwate, of Montgomery county, Pa., in an address before the Board of Agriculture at Bloomsburg in December, 1885, is reported as saying: "We find it pays to macadamize the roads, and our people would not like to be restricted to a tax of seven mills, because sometimes we want to spend a great deal more than that. We have learned that it pays to make good roads no matter what they cost. Everybody says 'if you will make the roads good we do not care for the tax.' It is when you have nothing to show for the money expended they complain, which is the objection to this working out system."

Any enterprise which reduces cost of transportation of crops and merchandise 40 per cent., adds to the annual income an unknown large per cent., and increases the value of land 25 to 50 per cent., should commend itself to the self-interest of every farmer in the State. It would be difficult to devise any scheme that would contribute so largely to the general prosperity as a large and immediate outlay, judiciously expended in the construction of first-class roads.

The road tax annually collected in the county of Allegheny amounts to about $140,000, and for the entire State, according to the best estimate obtainable, it amounts to the enormous sum of about $4,000,000. What have we to show for it? What a comment on the present inefficient methods these figures afford, in view of the condition of the roads at the present time.

We offer the following and respectfully present it to the Legislature of Pennsylvania, and recommend its passage.

T. P. ROBERTS,
T. H. JOHNSON,
A. DEMPSTER,
C. DAVIS,
A. KIRK,
Committee.

AN ACT

TO PROVIDE FOR THE LOCATION, OPENING, VACATION, CONSTRUCTION AND MAINTENANCE OF HIGHWAYS, ROADS AND BRIDGES IN THE SEVERAL COUNTIES OF THE COMMONWEALTH.

SECTION 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same, that it shall be the duty of the Court of Common Pleas of the respective counties within this commonwealth, to appoint a board of four persons, who, with the county engineer or surveyor, shall be constituted a commission to classify all the thoroughfares in the county, not included within corporate boundary lines, and to divide the same into three classes, to be styled, respectively, highways, roads and lanes. "*Highways*" shall include all those radiating from the county seat to other populous points in the county, or to the boundary lines of the county, and those connecting such other populous points; or those which by reason of their connection and extension in the same general direction, afford a continuous line of travel between such centres or to such boundary lines. "*Roads*" shall include all thoroughfares now designated as township roads, and which may not be classed as highways under this Act. "*Lanes*" shall include what are now styled "private roads" and which are used only for ingress and egress from roads or highways to individual property.

SEC. 2. Said court shall make such appointment within thirty (30) days after the passage of this Act, and it shall be the duty of said persons so appointed, to meet at the county seats of their

respective counties and organize by electing from their own number, a president and secretary, and shall then proceed without delay to make such classification, designating the several roads belonging to each class, and report their findings to said court. The classification thus made by said commission or a majority thereof shall be taken as final and conclusive in the matter, and the highways, roads and lanes thus designated shall be taken as such by all parties affected thereby. The compensation to be paid to said commissioners shall be fixed by said court, and paid by the county treasurer as other salaries are paid.

SEC. 3. In every township of this commonwealth, the qualified voters thereof shall on the third Tuesday of February, 1890, elect one person to serve for one year; one person to serve for two years; and one person to serve for three years, who shall be styled "road directors;" and at each annual township election thereafter, they shall elect one person to serve for three years; *provided*, that in any township which has now three road commissioners, no new election shall be required, except at the times of expiration of the terms of such incumbents; and *provided*, further, that the persons so elected as road directors, shall have been citizens of the township in which they are elected during the three years immediately preceeding the date of such election, and shall be freeholders in such township at said date.

SEC. 4. In case of any vacancy occurring from any cause, it shall be filled by appointment by the Court of Common Pleas of the proper county, until the next succeeding election, when the vacancy shall be filled by the electors of the township for the unexpired term.

SEC. 5. It shall be the duty of said road directors to meet on the second Tuesday of March, 1890, and annually thereafter, at the place where the auditors of the respective townships meet, and after being duly sworn by a justice of the peace to perform the duties devolving upon them by virtue of the provisions of this Act, they shall organize by electing one of their number as president, and one as secretary, and shall proceed to levy tax of not more than seven and one-half ($7\frac{1}{2}$) mills on each dollar of the valuation made by the township assessors for county purposes,

and shall certify to the county commissioners and county treasurer the amount of such levy; the same to be collected by said treasurer as other taxes are collected and to be set apart and kept as a road fund, which shall be paid out by him, on requisition of the county engineer, duly approved by the president and secretary of the road directors.

SEC. 6. The road directors, in conjunction with the county engineer, appointed as hereinafter provided, or his deputy or assistant, shall divide the township into road districts, and determine the prices to be paid per day for labor, the amounts to be expended in repairs and in permanent improvements during the year, and the amount to be expended in procuring materials, tools, or machinery deemed necessary to macadamize or otherwise improve the road; *provided*, however, that not less than thirty (30) per cent. of the road tax collected in each year shall be expended for materials to macadamize or otherwise improve in a permanent manner.

SEC. 7. The road directors, in conjunction with the county engineer, his deputy or assistant, shall have power to locate and open new roads, vacate existing roads, or change the location of the same, upon the petition of not less than six (6) taxpayers of the township in which the road is located, whenever they, or a majority of them, shall deem it necessary for the convenience or safety of public travel so to do.

SEC. 8. Upon receipt of said petition the said road directors shall notify the county engineer of such fact, whose duty it shall thereupon be to cause a survey to be made of the same, and make the necessary plans and profiles to show alignment, gradients, and lines of property affected thereby. In locating or changing such road he shall be governed: 1st, by ease of gradient; 2d, by directness of alignment; and, 3d, by least amount of damage consistent with public utility.

SEC. 9. The road directors and the engineer shall then be constituted a board of viewers in the case, and shall proceed at once to give notice in writing, delivered by messenger, to the property owners interested, where that can reasonably be done, and by hand-bills posted along the line of the road so proposed to be opened, vacated, or changed; said notices to designate a time not

less than ten (10) days from the date thereof, and a place on the line of said road when and where they will meet to perform the requirements of said view. They shall then and there, after hearing all parties interested therein, decide as to whether or not the prayer of said petition shall be granted. In case of a tie vote the decision shall be left to the Court of Common Pleas of the proper county, whose decision, after hearing the statements of the said board, shall be final and conclusive in the matter.

SEC. 10. In all cases wherein an affirmative decision shall be reached, the said board shall proceed to estimate the damages and benefits to each party in interest, and shall cause a schedule of the same to be made, showing the names of all persons assessed and the amounts of damages or benefits, and shall notify each of said persons of the amount with which he or she is charged or credited, as the case may be. They shall file said schedule in the office of the county engineer for ten (10) days from the date of such notice, during which time any person who may be dissatisfied with the amount of damages awarded or benefits assessed may appeal to the Court of Common Pleas of the proper county relative thereto, but such appeal shall not prevent or retard the opening and use of such roads; and the finding of the board shall be final and conclusive as to the necessity for and location of any new road; as to the propriety of vacating either in whole or in part any existing road; as to changing the location of any existing road; and as to all matters relating thereto, except only the amounts of damages awarded or benefits assessed. The Court of Common Pleas, upon appeal as aforesaid, shall have jurisdiction in the case, with power to approve, amend, or to set aside the findings of said board as set forth in the schedule aforesaid, and to order a review by a special board composed of the road directors of another township with the county engineer; and the findings of said special board shall be final and conclusive upon all parties interested. The cost of such views shall be considered and taken as damages, and be assessed as such, and where the damages exceed the benefits the excess shall be paid out of the road fund of the township.

SEC. 11. After the final decision of the case, or after ten days, if there be no appeal, the county engineer shall file the schedule

in the office of the county treasurer for collection, the same to be collected as other taxes or debts due to the county are collectable.

SEC. 12. It shall be the duty of the supervisor of the district in which any new road is located or existing road changed, as herein provided, to proceed to open the same within ten (10) days after the decision of the board relative thereto, and to place the same in safe condition for public travel, under the direction of the engineer, as soon as practicable.

SEC. 13. The width of all highways shall not be less than fifty feet, and of roads not less than forty feet; *provided*, however, that all existing roads and highways which have been established of greater widths than herein provided under the provisions of previous statutes, or which have been constructed by incorporated companies, and have passed to public control by lapse or surrender of charter, shall be maintained at the widths so first established.

SEC. 14. The said road directors shall each receive as full compensation for their services the sum of two dollars and fifty cents ($2.50) for every day employed in the performance of the duties prescribed by this act, which sum shall be paid out of the road tax fund by the county treasurer on the warrant of the president of the board, fully attested by the secretary, by affidavit that such time has been actually employed in such duties.

SEC. 15. It shall be the duty of the county commissioners to take cognizance of the classification so made, and to levy an annual highway tax on all property in the county not exceeding seven and one-half ($7\frac{1}{2}$) mills on each dollar of valuation made for county purposes. Said tax shall be collectable by the county treasurer as other county taxes are collected, and be paid out as hereinafter provided.

SEC. 16. The county treasurer shall set aside seven and one-half ($7\frac{1}{2}$) per centum of all taxes collected in the county for state purposes, which, together with the highway tax levied and collected as aforesaid, shall constitute a highway fund, to be applied to the permanent improvement and repair of the highways so designated, and of all bridges constituting parts of such highways.

Said fund is to be paid out on requisition of the county engineer as hereinafter provided.

SEC. 17. The county commissioners and the county engineer shall constitute a board for the improvement and repair of all highways and the bridges thereon. It shall be the duty of said board to determine the amount and character of work to be done on each of said highways in each year; *provided,* however, that not less than forty (40) per centum of the highway fund shall be expended in macadamizing or otherwise permanently improving the same. They shall, by advertisement in papers doing the county printing, solicit proposals for the furnishing of all materials needed, and shall let all contracts to the lowest responsible bidder.

SEC. 18. It shall be the duty of the Court of Common Pleas of each county of the commonwealth to appoint on or before the first day of January, 1890, and triennially thereafter, a competent civil engineer of at least ten years' experience as such, to be styled "the county engineer," and to serve for a term of three years. He shall give a bond in the amount required of, and shall receive the same salary paid to a county commissioner in the county for which said appointment is made; *provided,* however, that in every county in which there may now be a county engineer of said qualifications, no appointment shall be made until the expiration of his term of service.

SEC. 19. It shall be the duty of the engineer to make a map showing the location of all the highways, roads, lanes, and bridges in the county, together with their gradients; make all surveys for new roads and highways, and for changing location of existing ones; prepare plans and specifications for all work on highways, roads, and bridges; make and execute all contracts relative thereto, which may have been authorized by the board of highways or by the road directors; have supervision, direction, and control of all work in connection therewith; arrange with the road directors for the execution of all work decided upon by them; and appoint such supervisors as he may deem necessary to oversee the work and have it properly executed according to his direction; said supervisors to be citizens of the township for which they are appointed

and to have practical knowledge of road making. He shall make such rules and regulations for the guidance of the supervisors as he may deem necessary and have the same printed and distributed to the road directors and supervisors.

SEC. 20. The county engineers shall certify to the county commissioners, monthly, sworn and detailed statements of the amounts severally due for labor and materials expended upon the highways of the county, under contracts then in force, and the names of persons to whom the same may be payable, which statements, when approved by said commissioners, shall be sent to the county comptroller, who shall issue his warrants to the county treasurer, payable to bearer. The county treasurer, on presentation of such warrants, shall pay the same to the bearer thereof, and charge the sum so paid to the highway fund or to the road fund as the case may be.

SEC. 21. The county engineer shall, at the close of each fiscal year, make a detailed report to the county comptroller of all work done on highways, roads and bridges throughout the county, setting forth the number of miles of highways and of roads improved during the year and the cost thereof; the number of miles of highways and of roads previously improved and the cost of repairs thereon during the year; the number, location, and lengths of bridges built during the year and the cost thereof; the number and aggregate lengths of all bridges previously existing and the cost of repairs made thereon during the year; the number and length of roads or highways opened, vacated, or changed during the year and the cost thereof; together with a full report in detail of the condition of the roads and highways at the time of the report. And shall send a copy of the same, together with a copy of the road map of the county, to the surveyor-general, whose duty it shall be to make a connected plan of the highways of the several counties of the commonwealth; and shall make a summary report of the whole annually.

DISCUSSION OF REPORT OF COMMITTEE ON ROADS.

T. P. ROBERTS: I would like to state for the information of the Society that our report is not in the shape we desire. It is a

report merely of progress, but this Committee, if the Society wishes, will continue, adding any suggestions that may be given by the members. The proposed bill must go to Harrisburg before the next meeting.

WM. THAW, JR.: I would make a motion to the effect that the Committee get their bill into final shape and send it to Harrisburg. I don't think we have time to discuss it now.

ARTHUR KIRK: The accompanying paper shows the vast importance of the matter. The statements made cannot be disputed. Every taxpayer and every resident of the State knows that the road laws should be amended.

A. E. HUNT: I would like to ask of the Committee what exactly are the proposed changes that they wish to recommend in the improvement of roads. One or two that I thought of were the change of the grades and the shortening of the routes and, in some cases, the macadamizing of the roads. They did not suggest the macadamizing of all the roads. What was the idea of the actual time that they want to have put on the roads. Was there any direct plan suggested by them? If so, I did not get it.

T. P. ROBERTS: It is there. I would like to tell Captain Hunt that the laws of Pennsylvania are a complete blank on the subject of roads. So far as our Committee understands the legislation it refers the matter to the township authorities. There are about 30 townships in each county, and as referred to in the paper, it very often happens there are poor townships between two large towns and these towns have not the authority to make a road across such district. This classification of roads is a good thing, the idea being to provide for the great thoroughfares from a general county fund, while the township roads will be built with money obtained from the local tax of each district. That is the great revolution proposed in the law. The same point has been embraced in other acts suggested at Harrisburg, but ours goes much further in the directions of management, etc.

WM. THAW, JR.: Is there anything in that bill which gives the general supervision of the main roads between towns to the supervisors? As I understand it they take the county roads.

A. DEMPSTER: As the law is now, the supervisors are elected by the people. The people work out their taxes on the road and make it the occasion of a general jollification, with but little work. This bill provides for putting all the work under the direction of three road directors. The engineer shall appoint supervisors who must be experienced in road making; men of good common sense, working under the supervision of the engineer.

The classification of highways designates the roads that will be county roads. They are under the control of the county engineer and the county commissioners, who shall make application of the funds for the purpose of their improvement—those produced by the county taxes. The funds for the improvement of the township roads are produced by taxation of the township itself—a local taxation for local improvement.

Then there is the opening of roads. As it now stands, the law permits the road to be laid down on the ground that satisfies the views of the people. In this case the engineer shall be the judge and shall first have the road laid out, establish the gradients and then the alignment, and it don't make any difference whether it suits the people who petitioned for it or not. It is laid on the best grade and the best ground and then the people can submit their appeals as to the amount of damages or benefits they may be assessed.

T. P. ROBERTS: That is just the same as railroads.

J. REESE: I was wondering about the railroads and how they were going to be affected by this. It is a good thing to have the assessment on the county for county roads and on the townships for township roads, and both constructed under the direction of an engineer and the proper authorities. Now, railroads are going to be benefited by this movement very largely. Do you provide for the assessment of railroad property in making these roads?

A. DEMPSTER: Whatever property they have assessable will be assessed.

J. REESE: How is it with the country districts?

T. P. ROBERTS: They will, under this bill, be assessed as elsewhere.

A. DEMPSTER: Not the tracks, but all the property will be assessed.

J. REESE: What do you call property? Nothing but the right of way?

A. DEMPSTER: The right of way has by law been made non-assessable.

A. E. HUNT: Col. Roberts did not understand my question exactly. My question was to this effect: Is there anything provided in this proposed bill and in the talk about it in this paper of the specifications for the improvements of roads. That is to be left, you say, to the county engineers. One may have an idea to build with clay, another with quicksand, and others have different ideas. How do you provide for uniformity?

A. DEMPSTER: The county engineer is the head. He gives all directions.

After discussion, on motion the Committee was instructed to prepare and forward a copy of the Act to our representatives in Harrisburg and ask for its passage.

After which Jno. A. Brashear gave a lecture on

OPTICAL GLASS.

I shall give you a little prelude to this talk on optical glass by quoting part of a paper which was read by a gentleman before the Physical Section of the American Association of Science, at their meeting in Cincinnati, in 1881. I read it to you to convey this impression, that a man had always better understand a little about what he is going to talk upon when he commences.

The writer states: 1st. That the admixture of silver improves the quality of glass.

2d. That large lenses can be built up of cemented bars of optical glass.

3d. The writer essentially ignores the most important factors in optical glass, and indeed treats the subject in apparent ignorance, theoretical as well as practical, so much so that it is astonishing that such a paper would find a place in the annals of the American Association of Science.

I have had propositions from some of the manufacturers of glass in our own city in regard to making optical glass, and as its demands are so much more rigorous and exacting than the *best*

glass we are making from day to day for commercial purposes, a few notes on the subject may be of interest to our Society, some of the members of which are to be counted among the most advanced glass workers in this vicinity.

In a description of the methods of making optical glass, I shall necessarily have to be very brief. I presume the most of you who have read anything about optical glass at all, know that Guinand, of Switzerland, was the first to make it in large quantities, and it is said that his discovery was made accidentally. He was hauling some glass intended for optical purposes in a wheelbarrow one day, when it upset, and the lump of glass rolled out and broke, annoying him very much because he was hoping to get something fine out of this glass. However, he selected some of the best pieces and melted them down in a prepared mould and this was the germ of the method of making optical glass, as made at the present day.

Chance's method is something like this: They select their material as pure as possible, melt it in a single-pot furnace, in a single pot, and having melted it very thoroughly they introduce a stirrer, sometimes a platinum one, though usually a clay stirrer. After the material is thoroughly melted the stirrer is moved around in the pot until the glass becomes very thick. The furnace is then heated up again and the glass made soft and stirred until the impurities are worked up as thoroughly as possible. After the impurities have been worked to the top, which takes considerable more time than the ordinary melt, the top is skimmed and the furnace is luted up and allowed to cool; the walls being very thick this requires a very long time. After the furnace is cool a portion of it is taken down, the pot is taken out and the outside broken off entirely. Four, five or six places are ground and polished on the face of the metal, and it is examined with a tourmaline lens for defects.

In this way they discover the good parts and cut out whatever discs they can get, and in some cases they find very excellent pieces.

The process used by Pfeil, at Paris, is somewhat different. I visited both of these works while in Europe. They melt their glass in large pots, which after slow cooling are broken off the glass, the glass usually being formed more or less broken. They

examine the pieces very carefully with tourmaline lenses and diffuse and select the best, which they re-melt in moulds made of clay. Great difficulty is experienced in making large lenses. The 36″ lens for the Lick telescope required no less than 19 melts, using a great amount of material.

Mr. Mantois told me the final process was something like this: Having found a lump which gave evidence that a good disc could be made out of it large enough for the purpose desired they examine it very thoroughly in order to find stria, or whatever defects may be in the glass. They then carefully grind these out.

For instance (illustrating), here is a lump of glass, irregular in shape, like this, and here is an impurity in the interior. They go to work and grind until they have taken out the imperfection. Understand, now, I am talking about the most perfect optical glass.

Mr. Mantois had in his shop a piece which he said would likely turn out the largest piece of perfect optical glass in the world, and which will be exhibited at the Paris Exposition. It will probably be large enough to make a 40″ lens. It would take him three or four months to grind out the imperfections, because in doing this they must be very careful, for the glass is liable to shatter from the molecular strain in it. No one has ever been able to put glass in such condition that there will be no molecular strain in it whatever. These lumps are then put into a mould of whatever shape they are to be made. The glass must be brought to a heat very slowly. In the first place a clay base is made like this (illustrating) and a clay ring is set on the top of it, made of very fine clay. That ring, in the case of all large lenses, is split into two parts, and a wire is wrapped round it three or four times, simply to hold it together.

When working this glass the temperature is brought up very slowly until it is very little above a red heat.

Now comes the critical operation of tempering the glass, that is, of allowing it to cool so slowly that each molecule, or each crystal, or whatsoever you may choose to call it, shall get into its normal or natural condition.

After the furnace has been brought to the heat which will allow the glass to settle, they lift off the "muffle" or cover and draw

the disc toward the mouth of the furnace. By critical examination it can be determined whether there are any impure particles in it which can be cut out. They reach into the pot and pull up the glass with a pair of long-armed shears and keep pulling it up carefully until the impurity is reached, when it is cut off by the shears. When this is done it is very necessary that the place chipped off shall fall back upon the top of the glass without overlapping, because if it does, stria is almost certain to form in the spot. One trouble in getting glass absolutely free from stria is that the clay of the pot melts off into it, which glass men understand more about than I do. In the case of flint glass it is one of the most difficult things they have to contend with.

After the impurities are eliminated as far as possible the furnace is allowed to cool for two, three, four or five weeks, sometimes as long as three months, in order that the glass should be perfectly annealed. At Jena, however, they melt down the discs in moulds inside of a heavy copper vessel in which a stream of gas is allowed to play, and this stream of gas is regulated by an automatic regulator, and in that way they have produced some of the best annealed glass that I have ever seen, indeed, my assistant, Mr. McDowell, is so biased in favor of the Jena glass that he is hardly willing to work any other. I have here a number of specimens of the Jena optical glass. You will find them quite transparent and free from color, as is quite marked in these specimens.

(Mr. Brashear here exhibited several specimens.)

This, then, is the method of making large discs. The ordinary "discs," however, are melted in square moulds. Some of them are ground and polished on the faces, and warranted when they find them absolutely free from defects; and I will call your attention now, very briefly, to some of the defects of optical glass, and which may be interesting to some of those who are interested in glass-making of any kind.

Here is a fine piece of glass made on the South Side, and is much clearer than some made in Paris. But it is imperfectly annealed. A glass manufacturer, who has gone to his rest, a very excellent man he was, too, Mr. John Adams, once said to me: "How can you tell when glass is annealed?" I told him it would

be a very unfortunate thing if an optician could not tell when the glass was perfectly annealed, because in the case of large lenses you may put two or three or four or five thousand dollars' worth of work on them, only to find the glass useless from imperfect annealing. Fortunately, in the action of polarized light, we have a means of determining the condition of glass. I have here a piece of glass, which was made by Chance Brothers & Co., which was purposely left unannealed, and which can be examined after this little talk is over.

This piece of glass would be absolutely useless for an optical instrument on account of its imperfect annealing. Here is a little piece of ordinary plate glass which was annealed at Tarentum, and which shows no evidence of strain. I could make a very fair lens of it.

The next difficulty is that of meeting imperfections on the inside of the glass, which we generally call stria. Some people will take up a piece of glass, and will find many little bubbles, and think it would be absolutely worthless for an object glass.

In the case of the great Washington glass, I presume there are at least 50 bubbles, but they do not affect it in any serious way. They only produce a very small defraction, which I need not stop to explain. But with stria it is a very different thing. Recently we had a piece of glass in which this characteristic was so prominent we could scarcely see anything but stria. Indeed, much of the so-called optical glass we get in this country, which is used for camera lenses, for ordinary opera glasses, and for a great many of the small telescopes, is very impure on account of stria. Here is a very fair lens to the ordinary eye, and it is impossible for you, by looking at it, to detect the imperfections. In fact, the flint glass we got from the Jena people was usually so good that we did not suspect any impurities, but finally we found it was necessary to test every one they sent. This glass, which as a 4″ objective would be worth one hundred dollars if it were free from stria, is not worth anything as you see it, on account of the stria in the lens. The method of detecting stria is very simple. It is by means of the diffused light from a candle or lamp concentrated on the suspected lens by a good convex lens, and by its aid a child can detect stria.

There are other imperfections met with in glass, such as *unequal* density, *i.e.*, the thorough incorporation of all the particles, etc. It is absolutely necessary that in the process of manufacture every impurity be eliminated.

There is a way the optician has of eliminating an error produced by stria if it is not too prominent. Let us suppose that we have here a lens that has stria, not too prominent. We rub the glass with the tip of the finger on which rouge or peroxide of iron is placed, so as to get a "hole" in it which will throw the light that comes through the striated part from a direct line and diffuse it, so that when it reaches the focal plane it is quite harmless. This is the method the Clarks use in eliminating aberrations which they cannot cure in any other way. This method will do when the stria is small, but when there is a great deal of it in the glass, it is worthless for optical purposes.

In purchasing glass, you can buy the ordinary discs and run the risk of getting stria or not, the warranted discs costing so much that it is cheaper to buy the discs that are not warranted and get two out of six, than to purchase the warranted discs. But when we wish to get discs above four inches we always buy the warranted discs. The manufacturers always take these warranted discs, grind them roughly and polish them, examine carefully and test with diffused light. I had the privilege of testing a great number of large discs for lenses while at Chance Brothers. We have no trouble in getting rid of stria usually if it is near the surface of the glass, for then we can grind them out, but if the stria is in the centre of the lens we have to throw it away.

I see no reason why our Pittsburg people could not turn out optical glass as well as it is done abroad; we have the best material and the best fuel in the world, and we certainly have the brains and the enterprise,—if carried out intelligently,—but there is a wide difference between ordinary glass and that used for astronomical instruments.

Society adjourned at 10½ o'clock. S. M. WICKERSHAM,
Secretary.

April 16th, 1889.

Society met at their rooms, 8.15 p.m.

President J. A. Brashear in the Chair.

Vice-Presidents W. L. Scaife and A. E. Hunt.

Directors T. P. Roberts, C. Davis, William Metcalf, Max J. Becker, and thirty-five members and visitors present.

H. S. Fleming and C. H. Tebbetts were duly elected to membership.

A. E. Hunt read the following paper, illustrating it by a diagram on the blackboard:

ON THE TESTING OF METAL, AND TESTING MACHINERY; WHAT THEY ARE FOR; WHAT THEY ARE.

First, it is necessary to give some definitions.

A definition is a short description which shall include every possible case of the subject and exclude everything else.

Matter is a general name given to the substance which, under an infinite variety of forms, affects the senses or occupies space that has length, breadth and thickness.

Force is whatever produces or opposes motion in matter.

The great forces which produce the constantly changing form and position of matter are called:

Internal or Molecular Forces,
Attraction of Gravitation,
Heat,
Light,
Magnetism,
Electricity,

and one other, of which we know even less than of all the others, called Vital Force. Concerning the real nature or the "why" of any of these great forces, we are almost entirely ignorant. We say that they exist, because we see their *effects* upon matter, but whether they are merely properties of matter, or are forms of matter itself, are like the acts of creation, at present beyond the human ken.

Internal or Molecular Forces are of two kinds, those of Attraction and those of Repulsion. It is to only one of the four great divisions or kinds of Molecular Attraction, namely, Cohesion, that we have to consider to-night, for the other three forms of Internal Attraction, namely, Adhesion, Capillary Attraction and Chemical Affinity, do not enter directly into the quantities of Force measured by ordinary metal-testing machines.

Cohesive Attraction is that force which binds together atoms of the same kind, and it varies greatly in different substances accordingly as the nature, form and arrangement of the atoms vary; these modifications of the Force of Attraction, acting at insensible distances between the atoms of different substances, give rise to certain important properties in bodies which are called Elasticity, Tenacity, Ductility, Hardness, Brittleness, Malleability, Pliability and Flexibility.

It is the combination of these important properties in metals that give their chief uses in the arts. And it is to certain technical measures of some of these properties of metals that ordinary testing machines are designed to either pull specimens placed in them apart, or to crush the particles together, or to bend them, and have ordinarily a weighing or measuring apparatus to indicate the force necessary to accomplish the desired results upon the specimens.

The results of tensile and compression tests are usually calculated so as to be reported in pounds per square inch of section tested for the sake of uniformity in comparison. The results obtained from ordinary testing machines are technically called Elastic Limit and Tensile Strength, in tensile tests; and Crushing or Compressive Strength, in compression tests. In tensile tests, also, the amount of permanent extension, usually expressed in percentages in any given length, usually 8 inches in small specimens, is recorded; also, the amount of reduction of area of the specimen, usually expressed in percentages of the original area of the amount of reduction in the area in the specimens, is measured. These last two terms are necessary, for they are the measures of the flow of the metal, that is, of its ductility; and, as you all know, for most purposes for which metals are made, a certain

amount of ductility, which is the opposite of brittleness, is required; and for structural purposes as much ductility as can be obtained in connection with the necessary tenacity and hardness is wanted.

The elastic limit in tensile tests is the force or load required to stretch the specimen to the point where the increments of extension are no longer proportionate to the increments of load applied. It is usually determined by the drop of the beam of the testing machine, and by its remaining down through several hundred pounds increase of load occasioned by the considerable flow of the metal in extension at a point a little above the elastic limit. Another method of noting the point of elastic limit is to chalk the face of the specimen near one end, and to place one leg of a pair of locked compasses in a prick punch-mark near the other end of the specimen, to mark a line across the chalked face, and to note the strain at which the compass point marks a double or perceptibly broader line on the chalked face of the specimen. But these methods are at best crude, and the personal equation and limit of error due to inaccuracies of measurement often amount to several thousand pounds.

The latest designs of testing machines have an apparatus that plots the increments of extension as well as records the corresponding loads applied. Such apparatus, or those designed to measure by micrometer and electric bell attachments to the extensions, are the accurate methods of obtaining elastic limit.

The modulus of elasticity of a specimen of metal is the ratio of the product of the load applied up to the elastic limit, times the length, to the product of the area of the section, times the increment of extension. The data for it is obtained by the aid of the micrometer apparatus described above, by which measurements of extension are easily read to the ten thousandths of an inch.

The modulus of elasticity of wrought-iron ranges from 25,000,000 to 27,000,000, and of steel from 28,000,000 to 31,000,000 for soft steel up to about 40,000,000 for very hard steel.

The results of crushing tests are usually calculated to pounds per square inch, although the specimens are, for stone, brick and light material, 2-inch cubes, and in iron cylinders of from $\frac{1}{2}$ to

¾ inches in diameter and 1 inch in length. The height of specimens for crushing test has considerable influence on the specimen to resist crushing. The forms of failure under the crushing test are by splitting, shearing, of sliding, bulging, by buckling or crippling, or by cross-breaking. Ordinary red brick have a resistance to crushing in pounds per square inch as follows:

Red brick, . .	800 pounds.
Limestone, . .	4,000 to 5,000 pounds.
Granite, . . .	6,000 to 11,000 pounds.
Sandstone, . .	3,500 to 6,000 pounds.
Brass, . . .	10,000 to 12,000 pounds.
Cast-iron, . .	100,000 to 150,000 pounds.
Wrought-iron, .	36,000 to 40,000 pounds.

Transverse tests for structual material are made ordinarily to show the amount of deflection under the given load and under given distance between bearings. For cast-iron it is also used to show the relative strength of the metal; and an ordinary test for cast-iron is: In bars of 1 inch square, and when supported by knife-edges 4 feet 6 inches apart, they should be able to carry a load of 500 pounds without rupture, and without a deflection of more than 2 inches from the centre.

The best forms of testing machines for practical use have the specimens strained between two heavy plates, the upper one being held stationary on four stout pillars, and the lower one being moved by means of straining-screws operated by nuts and gearing; the power being transmitted from a belt upon a pulley driving a main shaft which is attached to the gearing.

The component parts of the machine may be classified under three heads:

1st. The straining mechanism.

2d. The machinery for communicating the motion to the straining mechanism.

3d. The weighing apparatus.

The straining mechanism is an upper fixed plate supported from the base of the machine by four heavy, stout pillars, which

rise from the main platform of the machine. This upper plate, as well as the movable lower plate, has square central openings, in which are placed, in the best machines, ball and socket joints, and inside of this a set of wedges with the interior faces serrated to facilitate the gripping of the specimens. By means of ball and socket joints the specimens adjust themselves parallel to the line of greatest stress and a straight pull is thus secured.

Better forms of wedges of late, also, have the interior face convex, which assists in the centring of the specimen, as well as securing a firmer grip upon it. This, however, is not as necessary in machines having the ball and socket joint. Four steel straining-screws pass through the holes at the corners of the lower movable plate and through openings in the levers and bed-plate, and have at their base driving nuts which are attached to the movable gearing. The top of the movable plate is bolted to the ends of these screws. Feathers fitting into longitudinal slots cut through the heads of the screws prevent them from turning. They therefore either rise or fall, carrying the lower plate with them, as the driving nuts are rotated by the driving mechanism below.

The main platform of the scale to which the weighing mechanism is attached rests directly upon the short arms of the main levers of the testing machine, they in turn resting upon cast-iron pillars rising from the bed-plate itself. The main platform of the machine rests wholly upon the main levers, and any pressure upon this platform is directly transmitted to it. To keep it in position, iron bars run from the bed-plate through the four corners and are secured by nuts having thick rubber washers, which serve to take up the shock occasioned by the sudden giving way of a large specimen.

The four long driving nuts, which transmit the power from the driving mechanism to the four main screws of the machine, are held between a collar which bears against the bed-plate and an iron plate at the bottom of the box. Wedges enter below these plates, having long handles which reach beyond the box. By means of a screw-thread, cut on their ends and nuts turned from the outside, these wedges can be forced in so as to take up any undue slack the nuts may have.

Above, where the nuts tend to bind, they turn on conical steel rollers running between steel plates. The upper steel plates bear against the collars, which are separated from the bed-plates by rubber washers.

Each nut has a large geared wheel which engages the central pinion, and are all turned by it in the same direction. These gears engage in sets of two on opposite sides of the pinion, one set being placed above the other. Another gear, K, on the lower end of the central pinion engages the bevelled pinion on the shaft, which is turned by wheel, M.

Between the lower shaft and this wheel is placed the changeable speed gearing, O. A sleeve, P, sliding on the shaft, but turning with it, carries a large and small pinion, either of which can be thrown into gear by the means of a lever.

The power from the engine is transmitted by means of pulleys which are clamped to the main shaft of the machine by means of Frisbie friction clutches. Sliding on the shaft between them is a double cone, operated by the main lever, which starts and stops the machine. When this lever stands vertically, both pulleys turn on the shaft; on being forced over in either direction, one set of clutch-jaws is expanded by the cone, and the pulleys to which they belong are clamped to the shaft and a motion in either direction given to the machine.

By combining the changeable speed gearing, the pulleys and the slow-motion attachments, four different rates of speed can be obtained for motion downwards, and two for motion upwards, in the ordinary testing machine.

The weighing apparatus consists of levers transmitting the weights to a beam upon which the weight is slid along, as in ordinary weighing apparatus. The main levers are ordinarily three in number, but are so constructed as to act as a single lever. The middle one of these levers is longer than the others, and runs back to a point nearly under the rear screws, where it branches into two arms, each arm being forked to allow the passage of a screw. Knife-edges support the rear legs of the platform, while the lever rests on two knife-edges upon pillars rising from the bed-plate. This lever receives the thrust from the two rear columns.

The two short levers, which receive the thrust from the front columns, are of equal length and curve outwards, each supporting two of the four front legs of the platform upon knife-edges. Under the platform the three levers run parallel and they find their support in a stirrup suspended from the second multiplying lever. The second multiplying lever is placed above and parallel to the first, and is of the same class; the resistance being between the fulcrum and the power, which is transmitted from the short arm of the beam by the rod, *n*, to the knife-edge, *m*.

The strong iron frame-work encloses these levers and is secured to the box by a diagonal brace. From this frame-work rise the supporting and guiding arms of the beam. The guiding arm carries suspended from its short arm a balance weight. There is also a cylindrical poise, running on a screw, which serves to adjust the beam. The beam of the machine is graduated into thousandths of pounds, and is balanced for the load applied by a poise weight, which travels along the beam.

Power applied to the extremity of the beam is multiplied, in the 200,000 pound Olsen testing machine, 4,651 times by the levers.

Compression test specimens are crushed between the platform and the lower plate, or upon a suitable anvil placed upon the lower plate.

Where the ultimate resistance of a material for tension or compression is to be determined, one man can easily manage an ordinary testing machine. When the extensions inside of the elastic limit have to be measured, an assistant is needed in the measurement of the extensions; one man running the power of the machine and the weights, the other making the measurements of the extension.

The best forms of testing machines now in the market cost about:

$900 for the 50,000 pound testing machines.

$1500 for the 100,000 pound testing machines.

$3000 for the 200,000 pound testing machines.

Larger testing machines for pulling full-sized members of bridge structures are used by the bridge companies; the Keystone Bridge Company, of this city, having a machine of a capacity of 500,000

pounds; the Union Bridge Company, of Athens, Pa., having a machine with capacity of 1,000,000 pounds. These machines are all horizontal and have the specimens fixed in a strong head at one end of the bed-plate and the other plate connected with the arm of a hydraulic or steam piston; the strain being applied by the movement of the piston backward or forward in the cylinder. The measurement of the strain being, ordinarily, pressure gauges indicating the actual pressure per square inch upon the piston-head in the cylinder, and with the area of the piston-head being known, the actual strain can readily be calculated.

Discussion of Mr. Hunt's Paper on Testing Machines.

T. P. Roberts: I would like to ask what has become of the Government testing machine?

Mr. Hunt: At Watertown? It is still in existence. It is probably the best machine in the country. Mr. Metcalf has just interrupted me to say the best in the world, and I can readily believe it. The reason is that for a large machine it is so accurately balanced and free from friction. The forms of testing machines I have described are not the most accurate. You can readily see that there is less friction in a hydraulic machine than in a screw machine. The machine made by the Emery people, of which there are but a few on the market, is the best machine for scientific work upon small specimens, or where the strains for very small increments of load are to be measured. The only trouble with the Watertown machine is that it is impossible for any common body to use it. It is under Government espionage. No appropriation is made for its use, and if you send samples for testing you are lucky to get results in a year's time. It is an elegant machine, however, and is kept in good condition, but it might as well be rusting, for it does no one any good.

William Metcalf: I am very proud of that lecture of Mr. Hunt, but I wish he had gone on and defined some of the properties he mentioned, such as ductility, brittleness, hardness, etc., and we could have had some fun.

Mr. W. L. Scaife: I should like to ask Mr. Hunt, whether,

if he had two specimens of any material exactly the same, and tested them, say, one in two minutes, the other in four, he would get in both cases the same results for tensile strength and elongation? In other words, whether time has not something to do with the results of these machines?

A. E. HUNT: That is one great advantage of machines of this character over the hydraulic machine—the strain is put upon the specimen by means of the pitch of the screws and not by the increment of pressure due to the pumping. With this form of machine, where the load should be applied steadily, the impact does not enter into it as it would with the hydraulic machine, but undoubtedly you can get different results. The more constant the pressure is applied, the higher the tensile strength and elastic limit and the lower the percentage of elongation and reduction of area. Faster speed lowers the results in ductility and increases those in tenacity. Still, the machines will show a little difference. In this connection there is an old trick of the trade, that if your specimens are low in tenacity and you want to bring it up, you work the machine quicker.

W. L. SCAIFE: For very accurate work and for comparison of results should not each tester have his equation of error depending on his methods of operation?

A. E. HUNT: Undoubtedly. The thing is reduced more with the mechanical system than where regulated by hand-power.

MR. MATLACK: You do not seem to have understood the question. With the present pumps they put on hydraulic machines, where they have from 3 to 6 inch throws they get a perfectly steady strain. But as I understood the question it was whether in using these machines, the speed of the lower head at 2 inches per minute, and also at eighteen minutes to 1 inch, whether you would not get a greater flow of metal in the slower strain than in the more rapid strain. It has been demonstrated in practice that is the case, showing greater ductility but less tensile strength.

W. L. SCAIFE: Suppose you have a brittle metal, like cast-iron, cannot an inspector put the test-pieces in the machine so that he will get one result at one time, another at another, or so as to

bring a side strain on it, and reduce the tensile strength considerably?

A. E. HUNT: Yes, sir. That is one of the very important points with reference to the testing machine; that is, that the specimens are put in centrally, parallel to the line of strain. You get a shearing-strain the minute you put your line of power outside the central line or longitudinal axis of the specimen. It often amounts to a very serious error in getting the results of a specimen. This effect can be almost always told upon the specimen, if ruptured, by noting the lines of flow of the metal.

WM. METCALF: That may be a very good machine for buyers, but not nearly so good as the old-fashioned machine for sellers. The machine I was trained on was the old weight machine. It was run by a crank, and that crank was worked by an Irishman's arm. We had a minimum and maximum limit, and it took very little experience in that Irishman's arm to get the specimen to break in the right place. You could do the same thing on the present machines, but you would be caught at it.

T. S. WHITE: Should there not be a standard rate of speed, or is there such?

A. E. HUNT: There practically is, but there is none specified in any of the specifications that I know of. At the same time, most inspectors are aware of these points, and they usually watch to see that the specimen is pulled in the way it should be, and with the normal speed.

MAX BECKER: There is always required, in testing specimens, a certain expenditure of force to overcome the initial friction; I know that was particularly the case in the older kinds of machines. Of course, the results in smaller specimens would be different from those with larger specimens that required greater expenditure of power to break it, while the initial force would remain constant. Is there any formula to equate this difference? There might be some way by which these smaller and less perfect machines could be adjusted on the basis of the perfect Watertown machine so as to get practically the same results for eliminating this initial force and get the amount required for an actual deter-

mination of the strength of the material on an equal basis for all sizes. Has the thing been brought to that degree of perfection?

A. E. HUNT: Not to the degree it ought to be, and yet to a very considerable degree it has been by means of the regulation of weights and careful records kept with reference to that point, and comparing with the Watertown machine. I have within the last two months started a series of these tests, made of open-hearth steel in $\frac{3}{4}$ round tests, which we are testing in such manner as to get the average of the matter upon the standard machines of the country. I have this matter under way, but not in shape as yet to submit, but expect to report to the Society upon this point later.

MR. MATLACK: In that same connection, the 200,000 pound machine placed in the Boston Navy Yard is so delicate that if you put a 2 pound weight on the platform the beam went up, although it was only graduated to 10 pounds; and if this 2 pound weight would do that, the error must be very slight.

T. P. ROBERTS: In your sketch you show that H is higher than H primor; did I understand you to say this?

MR. HUNT: Yes, sir. The sketch is not drawn to scale.

MR. KOCH: I would like to say something about testing machines. The trouble is they are far too slow. If this country means to handle its trade we must have machines that will work faster. In the old country, in one mill with which I was connected, we kept three machines, and with them was connected a large fitting and turning shop, with planers and millers. We tested night and day. We have pulled three tests in a minute, but twenty per hour was about the average. If we could not do this we could not keep up on our inspection. This country will have to come to the same thing. What I am looking forward to is a testing machine that will work very much quicker.

The machines we used were perfectly accurate. Our results were compared with those of the Government machine which were taken in 8-minute tests, and they were the same. If you pull a test very slowly it will give you one result; at medium speed it will give you another, and very fast indeed, pulling at the rate of three per minute, when the specimens get so hot you can't touch

them, you will get the same results as in pulling slowly. We had to test rapidly, for the consumers were dancing around there waiting for their plates, and under such circumstances the inspector has no time to take elastic limit or anything else. If it makes 60,000 pounds and 20 per cent. in 8 inches that is all they want. The machine we used was an hydraulic machine. The machine was worked with a lever. We did not take the elastic limit, only the ultimate strength, and the results we got were as accurate as those obtained on the big automatic machine.

MR. MATLACK: Was that a horizontal machine?

W. E. KOCH: Yes, it was a horizontal machine.

MR. MATLACK: Were the grips used the same or similar to those used here?

W. E. KOCH: There were no two pairs of grips alike. We tried every kind of grips. The testing department kept about fifteen men busy all the time preparing, measuring, and putting the grips and test-pieces into the machine. We had to work in this manner; for instance, when we got a 10,000 ton order for plates from the Government, of which 500 to 600 tons per week were wanted, and we had to test nearly every plate, there was no time to do anything else.

A. E. HUNT: There are advantages about that class of machines, for while, as a rule, what is worth doing at all is worth doing well, unless you have some rapidly working machine you cannot make as many tests as you ought to. The advantage is not in the accuracy of the test, but in the many more of them you can make. Two points are mainly wanted: that the steel is strong enough, that is, has a sufficient tensile strength to answer the purpose, and that it has sufficient ductility. Enough tests must be made to insure the uniformity of the material; to see that the manufacturers have not put in some rail carbon steel in place of good structural steel, for instance.

W. E. KOCH: They do not test every plate now. I think only about one in a hundred, because the manufacturers kicked. They could not go on in that way. It costs too much.

MAX BECKER: In making tests of iron I believe it has always been taken for granted that after testing a specimen up to a certain

extent, then resting for awhile, and then starting the machine afresh, that it would require a higher expenditure of power than was indicated at the time before resting. I would like to know whether there have been any experiments made to see whether that holds good in steel? I can readily imagine why it should be so in iron, but not why it should hold good in steel.

W. E. Koch: It will happen every time. I have tried it hundreds of times.

Wm. Metcalf: I know a better way than that; that is, not to test at all. We frequently get demands from various parties to get a certain tensile strength, elastic limit, modulus of elasticity, etc., and we simply write back to them the truth, that we don't know anything about it, but if they want us to, we will send them a piece of steel that we do not think will break.

J. A. Brashear: I would like to ask of these gentlemen who do so much testing this question: Suppose you test a specimen, do you know at all that the pieces it is to represent will be *exactly* like it? If they are not the same, is it necessary to go to so much refinement in testing machines? I find in my experience in working materials whose molecular condition I can see by optical means, that there are absolutely no two pieces alike. I have yet to find absolute homogeneity in any material made by the hand of man. If we only find approximation to homogeneity I do not know that such absolute refinement is necessary in tests of this kind.

There is another question that has always interested me, and the answer Mr. Koch gave was *apropos* to that question. I have often thought in the testing of boilers, is it not dangerous to test to the limit? In other words, are the plates as safe after testing as before? My attention was called to that at the time the little incline was put up to the head of our hill, where a heavy test was made on the bar of iron connecting the car with the wire rope. I asked the builders this question, but they could not answer it.

A. E. Hunt: That is just exactly the argument often used by engineers. A common way of testing a railroad bridge is to load it with engines, so the load will be quite up to the maximum load the bridge is calculated for. A danger is encountered here, that there may have been some parts of the bridge overstrained, that is, beyond the elastic limit.

You ask the question whether one test will represent the whole lot of material? No, we do not know that it will. There are very many exterior causes for failure, just as you spoke of with reference to your glass. It may have been handled incorrectly, or improperly worked, which would not be determined by the test, but as to structural material it is now made mostly of steel. Steel is cast either from Bessemer converters by "blows," as they are called, or in open-hearth furnaces by "heats." The steel is tested in lots, taking a given number of tests of each heat or blow; and in this way experience has shown that the steel is reasonably homogeneous, so far as certain qualities are concerned. If it is properly handled afterwards there is no trouble, but if the steel is wrong in the first place, the tests will show that point and will cause its rejection. It will not necessarily prove, however, because you have good tests that all the material is right.

WM. METCALF: Mr. Becker raised a point as to whether if you strain a piece to its elastic limit point and let it rest, whether by testing again it does not show a higher strength? Wohler's experiments show that is true. It does. Now, then, I want to ask if it is not true that in testing a boiler or bridge it is not stronger after a rest than it was before, unless you start an incipient rupture somewhere. If your structure is broken down by the test that is the best thing you can do, for it will save life probably afterwards. The same rule would apply to a boiler unless you test it to the point of incipient rupture, which no man would do. He would test only up to the limit of safe strain. And all experience shows that to be safe.

A. E. HUNT: With reference to a boiler I will admit the force of Mr. Metcalf's argument. With reference to a bridge it is different. It may be only thought that you are straining each member up to a point of 8000 or 9000 pounds per square inch, but do you know that all those bars are just one length? It is not sure, and it may be that you have actually tested one member more than it was calculated for, more than it ought to stand; and, that being the case, that member will go that much quicker.

WM. METCALF: I do not see it yet. If it is tested within the limit of rupture then, after resting, the tensile strength has been

increased, and what has been done has been good instead of harm. I do not see yet the objection to tests of that kind. If one bar takes too much strain it ought to be pulled out so as to allow the other bars to do their part of the work.

T. S. WHITE: Is it not the case where the second test shows no permanent set of the bridge that it is a sufficient demonstration that the bridge is not injured by the test?

A. E. HUNT: That would be a good test. It is usually called for in specifications that the load shall be applied twice.

MR. MATLACK: In that same connection I would like to call Mr. Metcalf's attention to what I saw in the testing-room at Watertown some months ago. They were showing results of tests made of material strained slightly beyond the elastic limit, but had not yet come to a permanent set. After a rest of forty-one months a further test of the material showed the same elastic limit it had previous to the original test, so that would seem to corroborate your illustration of the one eye bar in a bridge which had been strained a little beyond the elastic limit and did not break. After a rest it would be as good as the rest of the bridge.

Society adjourned at 10½ o'clock.

S. M. WICKERSHAM,
Secretary.

MAY 21ST, 1889.

SOCIETY met at their rooms at 8 o'clock, P.M.

President J. A. Brashear, Vice-President W. L. Scaife, Director T. P. Roberts, 30 members, and 5 visitors present.

The minutes of April meeting were read and approved.

Henry Aiken, of Homestead; John McDonald, of Pittsburg; J. J. Keenan, of Allegheny; George H. Paine, of Swissvale, were duly elected to membership, after which Louis J. Clarke read the following paper, illustrating it on the blackboard and showing the working with the instruments themselves:

THE PHONOGRAPH AND GRAPHOPHONE.

At this time it is interesting to recall the fact that the Assyrians and Babylonians, 2500 years ago, used cylinders of baked clay upon which to record their ideas and history.

These cylinders, while intended pretty much for the same purpose as those of the phonograph of to-day, differ greatly from them in one essential particular. Those of the ancients have to be translated by such learned men as Rawlinson and Layard, while the ones of the present day speak for themselves—the phonograph or graphophone acting as interpreter.

You readily understand that the characters inscribed upon the cylinders in both cases are visibly equally unintelligible. Several years previous to Edison's first discovery, Faber invented a talking machine, modeling his apparatus after the vocal organs of the human throat. This was truly a wonderful machine, but of no practical value, being too complicated.

At a somewhat later date, Leon Scott invented *his Phonautograph*, a machine by which he could record sound vibrations and make them visible, but in no way reproduce them. W. H. Barlow, F.R.S., adopted Scott's principle, made some modifications and improvements, and styled the instrument *the Logograph*, some enlarged tracings from which I will presently show you.

The principle of this machine, as described in Prescott's *Bell's Telephone* is this: "The logograph consists of a small speaking-trumpet, having an ordinary mouthpiece connected to a tube, the other end of which is widened out and covered with a thin membrane of goldbeater's skin or gutta percha. A spring presses slightly against the membrane, and has a light arm of aluminium, which carries the marker, consisting of a small sable brush, inserted in a glass tube containing a colored liquid.

"An endless strip of paper is caused to travel beneath the pencil and is marked with an irregular curved line, the elevations and depressions of which correspond to the force, duration, and other characteristics of the vocal impulses.

"The lines thus traced exhibit remarkable uniformity where the same phrases are successively pronounced."

As I do not intend to enter into a discussion upon acoustics, I will pass on to the history of the phonograph proper. It was in the spring of 1877, while Edison was experimenting with a machine that recorded Morse characters by indentations upon paper and automatically transferring them to another circuit, that he conceived the idea of recording and reproducing articulate speech. It happened accidentally, in this way: While manipulating the machine he caused the paper tape on which the dots and dashes were recorded to be passed very rapidly beneath the recording-needle, producing a humming noise, like that of muffled voices, he immediately realizing that the problem of recording and reproducing speech and other sounds was practically solved. All that remained was to make some modifications of the apparatus—fitting a diaphragm to the needle and using paper tape soaked in paraffine.

The results produced by this machine were really startling—so startling, in fact, that the civilized world was very hard to convince that it was not all a hoax.

After a short time the paraffine paper tape was done away with and a cylinder covered with tinfoil substituted in its place. A few of these old tinfoil squeak boxes were manufactured in 1878 and sent all over the civilized world on exhibition, at which time, or since, doubtless many of you had an opportunity to examine, so I will not stop to describe them here.

These machines purposely sacrificed distinctness of reproduction for loudness of tone. The same needle being used both for recording and reproducing the sound, the record being reproduced once, it was of no further use, as it was destroyed by the needle passing over it the second time.

From this time until within the past two years, Edison was so much engaged with his electric light, telegraph, telephone, and other inventions, that the phonograph was laid aside and almost forgotten, but never abandoned, as many people imagine. It had been Edison's intention, at some future day, when he had more time, to develop and improve his invention, and at last he succeeded in doing so. In the *North American Review* of May, 1878,

he published a paper on the phonograph and its future, predicting the future uses to which the phonograph would be put.

These predictions have now been verified and the machine is in actual and constant use, and it may be safely asserted that within the next two years the phonograph will be as common as the telephone.

The principle of the phonograph, the present as well as the original, is this: A cylinder of some malleable material, such as wax, celluloid, or soft metal, is caused to *rotate at a uniform rate of speed.*

This latter is absolutely necessary, as upon it depends largely the proper working of the machine.

In the original machine the cylinder, which had a screw cut upon its shaft, was caused to move longitudinally, the diaphragm remaining still; in the modern, the cylinder simply rotates, the carriage carrying diaphragms moving along in an exactly similar manner to that of a slide-rest on a screw-cutting lathe.

However, the result is exactly the same: the record is cut in a spiral upon the surface of the cylinder.

To the back of the recording diaphragm is fastened a needle of peculiar shape, which, when set in motion by the vibrations of the voice, musical instrument, or by other means, cuts indentations representing the vibrations in the surface of the cylinder. I imagine it would be a very interesting study to thoroughly examine these records by means of a powerful microscope.

But to return. The instrument is then reversed, and in the case of the new machine the reproducer is swung into play.

This is very similar to the recorder, the needle being of slightly different shape and not being so sharp, and the diaphragms being somewhat lighter.

This reproducing needle then takes up the exact position of the recorder, and as it bumps over the uneven track left by the latter it sets its own diaphragm in vibration similarly to that of the recorder under the action of the voice.

This, in short, is the principle of the phonograph, and it only remains for you to examine the instruments I have with me to-night to thoroughly understand their workings.

It is a rather difficult matter to give an intelligible description of the modern phonograph, but I will do the best I can to make you understand its mechanism.

In the first place, an electric motor of peculiar design is used in driving the cylinder. This motor is a multipolar machine with Gramme ring armature 10 inches in diameter, having 40 segments.

The great diameter of the armature makes it rotate very steadily, acting as it does like a fly-wheel. The resistance of the armature coils being so low, a current of only 2 volts is necessary to give it sufficient speed to rotate the cylinder properly. The motor does not depend wholly upon the inertia of the armature for its steady movement, but a small and very perfectly made governor is inserted in the circuit, cutting off the current in an exactly similar manner to that of a steam-engine governor.

By means of a thumb-screw attached to this governor, the speed of the armature may be changed at will.

A record should always be reproduced in exactly the same speed with which it was made. That is to say, if you make a record with the cylinder revolving 100 times per minute, the reproduction should be made with the cylinder travelling exactly at the same speed. Otherwise, the pitch of the voice, music, or other sounds will be changed—lowered if the speed is decreased, and raised if the machine runs faster. You can readily see the reason for this.

The main shaft of the phonograph proper—that which carries the wax cylinder—revolves at right angles to the armature shaft, and is connected to it by a belt.

In the early phonographs Edison used bevelled gearing to connect these two parts, but he soon found that the teeth of the gears gave the cylinder a slight vibration, which was detrimental to the perfect reproduction.

The carriage upon which the diaphragms are fastened is given its lateral motion by a nut pressing against a screw cut on the main shaft. This screw has 100 threads to the inch.

In the case with the graphophone the record is cut at the rate of 160 threads to the inch. In the phonograph the diaphragms are

made of glass, about $\frac{1}{500}$th inch thick and $1\frac{3}{8}$ths inches diameter, the recording diaphragm being slightly heavier than the reproducing.

The diaphragms are set in metal cases, with their edges screwed between rubber bands, permitting them to vibrate most freely.

Edison experimented a long time upon different substances out of which to make his diaphragms, and at last determined that glass was the best, as not being affected by the weather, and being very elastic.

Until quite recently the point of the recording needle has been square, like that of an ordinary chisel, but within the last month has been changed to the form of a gouge, cutting a semicircular record.

This they find to be a vast improvement over the old style. Previously, the reproducing needle was simply a hooked piece of steel with a very sharp point. This more or less injured the record, so it has been replaced by a tiny steel ball highly polished, connected to an arm that is fastened to the diaphragm.

To the centre of this arm is pivoted, in a peculiar way, a weight that causes the reproducing ball to follow any unevenness in the cylinder.

The spherical shape of the reproducer permits it to fit snugly into the semicircular groove cut by the recorder.

For a long time the blank cylinders were made principally of beeswax, hardened slightly with other substances, but when the new needles were adopted this wax had to be discarded as being too soft. Just what the composition of the new wax is, none but the initiated (and I am not of that number) may say. However, it is very hard and brittle, and produces a very silky record.

By using this wax and the new needles nearly all the hissing sound that has been so annoying is eliminated; besides, the instrument is 100 per cent. more sensitive, a whisper being perfectly audible. In fact it seems to magnify the sound.

The Tainter & Bell graphophone is a very much simpler machine in its construction and operation than the phonograph, and for that reason it is easier to learn to operate.

But if a person will only take the pains to learn the functions

of the various parts of the phonograph, no trouble will be experienced in getting a perfect reproduction. In neither case is it as hard to operate as a type-writer, and a boy of ordinary intelligence can learn to handle a graphophone in ten minutes.

In the graphophone the cylinder, which is of paper 6 inches long and $\frac{1}{14}$th inch in diameter, and covered with a thin coating of black wax, is caused to rotate between two tapering chucks that press against it by means of a spring. The screw which moves the recorder and reproducer is encased in the guide at the top of the instrument, and is rotated by gearing from the main shaft—another case of the slide-rest principle. Both the recorder and reproducer are very simple in construction, in each case the diaphragm being made of mica. Ordinarily a treadle is used to run this machine, though any other source of power may be employed. The two machines differ in another very important feature. In the phonograph the carriage carrying the diaphragms rests upon two slides, between which the cylinder revolves. This carriage being so heavy is absolutely rigid.

Now, in the case with the graphophone, the diaphragm rests upon but one guide and upon the cylinder. By this arrangement the recording and reproducing needle follow any unevenness in the cylinder, so that it does not have to be so absolutely true as in the phonograph.

Another very interesting "talker" has been invented by Berliner, of Washington, the principle of which differs in many essential features from both of the instruments just described.

The substance upon which the record is made is a zinc disc rotated horizontally. This disc is first coated with collodion or some very thin varnish, which is allowed to dry.

It is then placed upon the instrument and given a steady motion by clock-work. The recording stylus does not produce indentations on the surface of the zinc plate, but is given a wavy motion similar to the logographic records previously shown you, and travels in a spiral from the periphery to the axis.

As the needle passes over the plate it removes, in a fine line, the varnish, leaving the metal bare. The disc is then removed from the machine, and with chromic or sulphuric acid the record

is etched, after which the operation is exactly the same as with the other machines. It is said by those who have had the good fortune to hear this instrument that the reproduction is simply overpowering, 10,000 people together being able to hear it with perfect distinctness. As you can readily see, this is not a practical business machine, but is more adapted for exhibition purposes.

But to return to the phonograph. Unlike the telephone, it is a complete machine in itself, not being dependent upon a central station and the number of other instruments in use for its value.

Then, again, the phonograph may be used in so many more ways than the telephone. Of course the two instruments should not be compared, as they have very different fields of usefulness; yet, to-day, many people smile when they hear the declaration that within a very short time they will be equally common.

To the person who has not given the matter very much thought, the phonograph appears to him only as a very amusing and novel plaything, and when the long list of its many applications is recited to him he is at first incredulous, and then begins to see how very short his sight has been.

Edison, in his article to the *North American Review* of May, 1878, gives a list of uses to which the phonograph would ultimately be put. This I here insert, with a few additions:

"1st. Letter writing and all kinds of dictation without the aid of a stenographer. 2d. Phonographic books, which would speak to blind people without effort on their part. 3d. The teaching of elocution. 4th. Reproduction of music. 5th. The 'Family Record,' a registry of sayings, reminiscences, etc., by members of a family in their own voices, and of the last words of dying persons. 6th. Music-boxes and toys. 7th. Clocks that should announce in articulate speech the time for going home, going to meals, etc. 8th. The preservation of languages by exact reproduction of the manner of pronouncing. 9th. Educational purposes, such as preserving the explanations made by a teacher, so that the pupil can refer to them at any moment, and spelling or other lessons placed upon the phonograph for convenience in committing to memory. 10th. Connection with the telephone, so as to make that invention an auxiliary in the transmission of permanent and invaluable

records, instead of being the recipient of momentary and fleeting communications."

When the instruments come into general use and all the principal hotels have them, what a boon it will be to the travelling men. Then the heretofore unhappy drummer may, for a small fee, send to his employer a verbal history of the day's operation, instead of having each evening to sit down and write home a long and wearisome epistle.

To the musical composer it will be almost an invaluable aid, for, while he improvises, all the harmony he brings from his instrument, which would otherwise be entirely lost to the world, may be recorded and transcribed at leisure.

The list of the various uses of these instruments is almost endless, new applications arising each day.

A secret process has been discovered by Mr. Edison by which a phonographic record may be reproduced 10,000 fold, so that shortly one will be able to purchase, for a very small sum, songs by our most noted singers, music from the celebrated performers, and speeches from the most famous oraters of the world.

Who would not be willing to pay one dollar for a cylinder containing a song from Patti—a song that you could hear not only once, but every day in the year?

To show you how much matter one of these cylinders can contain, two columns (2500 words) from the *New York Tribune* have been dictated to one graphophone cylinder, and a special phonograph, made by Edison, using a cylinder 8 inches long by 4 inches in diameter, four of which would contain the whole of *Nicholas Nickleby*.

I have endeavored to procure from the Edison laboratory some data in regard to number of vibrations in certain words, and other information of interest, but they have been too busy to furnish me with what I desire.

In conclusion, I would say that, having had so very little time to prepare this paper, I feel that I have not done the subject full justice.

In the course of his paper Mr. Clarke gave a description of a new invention by Mr. Edison whereby sound was reproduced not by a needle running over the indentations, but by a very highly-polished steel ball. The paper not fully explaining the point, the following interruption occurred:

W. L. SCAIFE: Does the ball turn on an axis?

L. S. CLARKE: The ball is solid. It does not slide over the record, but takes the place of a point.

W. L. SCAIFE: It does not revolve? Is it simply a spherical surface?

L. S. CLARKE: It does not revolve. It is connected to that rim on one side.

J. A. BRASHEAR: Suppose, in the cutting by the needle of the indentation effected by the action of the voice, that it would go down and then be raised up, would a spherical ball go down to the bottom? It does not strike me it would.

L. S. CLARKE: That is even so, and that is one point that I do not quite understand myself. I do not see how the ball can get into the sharp depressions.

T. P. ROBERTS: What is the diameter of the ball?

L. S. CLARKE: The ball, I should say, would be not more than $\frac{1}{80}$th of an inch, or possibly $\frac{1}{100}$th.

W. THAW, JR.: The ball must be less than that. It is practically a point, so far as the physical sensation is concerned.

L. S. CLARKE: The curious feature of it is that it works better than if it were sharp; and there is another feature of the thing, that there is a peculiar quality of the voice that is lost by the machine. It does not reproduce all the characteristics of the voice.

A MEMBER: What becomes of the shaving turned off by the gouge?

L. S. CLARKE: It is dropped into this box (showing on the machine). It comes off in the shape of powder.

After the conclusion of the reading of the paper, the following questions were asked:

A. DEMPSTER: Do you say you use mica in the diaphragm?

L. S. CLARKE: We use mica in the graphophone here.

W. THAW, JR.: You say that the glass you use is only $\frac{1}{500}$th inch thick?

L. S. CLARKE: Yes. (To another question.) It does break occasionally, though it is wonderful what amount of hard knocks it will stand.

W. THAW, JR.: What kind of glass is it?

L. S. CLARKE: I really cannot say.

After the Society had listened to some singing, reproduced,

T. RODD asked: How do they sing into it?

L. S. CLARKE: They sing right into the mouthpiece.

T. RODD: Is it in daily practical use?

L. S. CLARKE: Yes, sir; right in this city.

A MEMBER: For what uses?

L. S. CLARKE: Principally taking the place of a stenographer.

There was then reproduced the song "A Warrior Bold," by William Pruette, of the Emma Abbott Opera Company, which Mr. Clarke stated had been reproduced over 500 times.

L. S. Clarke also stated that he did not understand about the needle being so extremely sharp. He did not see why, in passing over the impression with the sharp point, such impression was not ruined.

W. THAW, JR.: The round ball will not take off the impression?

L. S. CLARKE: No; it does not destroy the record.

T. P. ROBERTS: Would not very loud noises while you were giving an exhibition have a reflex action?

L. S. CLARKE: Nothing is recorded unless the sound goes right into the machine. Yet I have dictated to the new phonograph in a hall at a distance of 12 feet.

J. A. BRASHEAR: You had the recorder in them?

L. S. CLARKE: Yes, sir; of course.

L. S. Clarke then reproduced some piano music, after which

A. DEMPSTER asked: How did you get the sound from the piano?

L. S. CLARKE: We have a large horn, which is placed near the machine.

The Society then listened to reproduction of music, etc., spending the remainder of the evening in this manner, adjourning about 10 o'clock.

S. M. WICKERSHAM,
Secretary.

JUNE 18TH, 1889.

THE Society met at their rooms at 8 o'clock, P.M., President J. A. Brashear in the chair.

Vice-President Scaife and Directors Roberts and Davis, with 47 members and visitors, being present.

After reading and approving the minutes of the May meeting, on recommendation of the board Walter C. Mellor was duly elected to membership.

A committee was appointed to report on the death of our late member, H. C. Dickinson.

The subject for the evening's discussion being

THE SOUTH FORK DAM,

Thomas P. Roberts opened the matter as follows:

It was mentioned in one of the papers that I would be prepared at this meeting to discuss this question, but that was made without consultation with me. I have prepared no paper, but will answer any questions I can.

There is one point I would like to correct, however. I was reported as saying, after visiting the dam, that the rainfall had nothing to do with the breaking of the dam. I want to have that corrected. I wish to say that there was, undoubtedly, a great deal of rainfall connected with it,—a cloud burst,—and the evidence of that is, I think, unimpeachable. The fact that a lake of possibly 500 acres rose in a few hours to the height of 7 feet 3 inches above its ordinary level, with, at the same time, its waste weir discharging to the utmost of its capacity, is evidence that there was a great deal of rainfall.

I would like to have information as to the area of that basin. It is a very interesting point yet to be determined. A committee has been appointed by the American Society of Civil Engineers to make a thorough survey, including the water-shed, and we may expect definite information on completion of their work.

In the edition of the *Engineering News* of the fifteenth of this month, Mr. Wellington, one of the editors, reports that the top of the dam was 18 inches lower than the end against the bank. This was in a distance of 300 feet, and taken with a hand-level. I am inclined to think such a measurement very uncertain; nevertheless, he has built up quite a theory on that. From his statements it would seem that the amount of water flowing through the waste weir was only about $4\frac{1}{2}$ feet deep. Now, it is positively certain that the lake rose fully 7 feet above the level of its low-water outlet, and, as the weir is at one side of the lake, it must have been 7 feet deep entering that place. The depth of water, so far as I could understand from the testimony of those who were present at the time, overflowing the dam was about 10 inches to 1 foot, and I do not think the sag could have been over 15 inches, or, at greatest, 18 inches, instead of 4 feet. Of course, when levels are taken, my figures may be changed. The width of the break in the dam I made to be 372 feet; it may be somewhat more.

W. G. Wilkins: Mr. Park informed me that they raised the embankment about 1 foot at the centre point; that the water began to go over the dam about 12 o'clock, and the dam broke between 2 and 3 o'clock. He walked over the dam at 12 o'clock himself. There was about 2 or 3 inches going over the dam at that time. Between 2 and 3 o'clock the front face of the dam was washed away so much that the pressure of the water back of it broke out a piece about 10 feet wide and 10 feet deep. From that time, he says, it was about 45 minutes—another gentleman says an hour—before the entire break took place.

T. P. Roberts (after making a sketch from memory, on the black-board, of the dam and the break), illustrating: This represents the road coming in from South Fork, passing right over the dam, or did before the dam broke. The break is 372 feet wide. In the ordinary stage the depth of water is about 62 feet, and total height of dam from foundations 75 feet.

The waste weir is here, and a bridge went over it. The interior slope was rip-rap, but here there was a piece of hand-laid wall. Here is the tower, built in the old canal times. The masonry foundations of that tower are now visible.

I made a cross-sectional sketch of the dam here, showing the stratification very distinctly, in layers of 6 inches to 1 foot. I do not think there was any place where these layers were over a foot thick. It is a little wavy, but very compact. Then there is a portion on the lower slope which does not seem to have been made with the same care, nor was it necessary. There is a great deal of rip-rap on the lower slope; I suppose 10 or 15 feet deep at the bottom. This part here, in the lower slope, seemed to be shaly earth. The entire upper half was a puddle wall. That puddle wall at the base was not less than 160 feet, rising to the upper edge of the road. I may say that none of the material that was last placed in the dam is remaining there now. I think I can speak positively as to that, because the statement has been made that 22,000 yards were required to fill the old gap, whereas, by my rough measurement, I found that about 100,000 cubic yards of material were removed from the dam. The original cost was about $17,000. It would cost now over $50,000 to repair the dam.

This puddle is well made and the dam was certainly intrinsically strong enough to resist any pressure. The trouble was from overflow. I understand from the statements of those on the ground it came over in a distance of 200 or more feet and about 10 inches deep. The washing away continued until only about 5 feet of that road remained, and then the pressure became too great for what was left to hold back the water. It is difficult to ascertain the time the water was passing out, because in their excitement they could not tell exactly; the statements vary from one-half to one and a half hours. One reason, I think, it took considerable time to flow out was, that the water was 70 feet deep at the time of the overflow, and the water was not probably over 30 feet deep just below the dam after the break. The section of the break was wearing deeper all the time, of course. So also was its capacity for discharge diminishing.

In regard to this waste weir, it is reported that it was very much obstructed, but I did not find that to be the case.

They told me that the water in the creek was unprecedentedly high all that morning, so I think the weir was discharging very freely. It must be remembered that the reason the marks are not distinct about this weir, is that the water was clear all the time it was discharging. (Mr. Roberts illustrated very freely from his sketch.)

Below the dam I noticed an immense bar fully 1500 feet long, from 5 to 12 feet high and 160 feet wide. It contains approximately 100,000 cubic yards of material. I was told by a gentleman familiar with the valley below, that it was a new deposit of material since the accident, so that it appears all this material has come from the dam.

A great deal could be done in the way of determining the quantity of water which fell. The rain began falling the previous evening. There had been a pretty hard shower in the afternoon, but not of very great length. About dark it began again and rained continuously throughout the night. A statement was made in the Pittsburg *Post* by a party who had been up there, giving a graphic description of the way those streams had risen, due to the tremendous cloud-burst. Little streams ordinarily only six inches deep had come up 5 to 6 feet, actually cutting earth from the hillsides, tearing holes in the ground, etc.

Now, if we had the area of that lake and calculations of the weir from the time it began to rise, we could get a very good idea of the amount of water that fell in the entire valley. Although, as the lake was still rising at the time of the break, the calculations will have an element of uncertainty about them.

Lewis S. Clark: I have no data except in regard to the dimensions of the lake. By actual measurement, made February 18th, 1888, the length, measured down the middle, was 10,188 feet, 1.93 miles. The line was kept out about the middle all the way down. The breadth opposite the lower end of the boat-house was 1734 feet, .32 of a mile.

W. G. Wilkins: Since the bursting of this dam I have been looking up the subject of dams. I find that hydraulic engineers say 6 inches in 24 hours is the maximum fall of rain that must be provided for in proportioning a waste weir. The signal service

officer at Altoona, so I have been informed, says, that during Thursday night, in about 10 hours, there was 5¼ inches fall, or nearly 12 inches in 24 hours.

Col. Unger says that a wooden bucket left out accidentally all night in front of his house, contained in the morning 8 inches of water. Now if this weir had been proportioned in accordance with hydraulic formulæ, which were based on previous known rainfalls, this waste weir would probably not have been too small for a rainfall of 6 inches in 24 hours. As the results show, it was too small for a rainfall of 8 inches in 10 hours.

In this connection I would state that in the *Engineering News*, I forget of what year, I found a description of a dam in California which drains a water-shed of 390 square miles. It was 110 feet high, 125 feet base and 15 feet width on top. The waste weir for this dam is 20 feet wide and 5 feet deep. If the water-shed of Conemaugh Lake was 50 square miles, and had a waste weir of the same size as that one in California, it would be proportionately 8 times larger. The actual proportions are for the California dam 100 sq. feet, for South Fork Lake nearly 500 sq. feet, or, in proportion to the water-shed, 40 times larger.

I think that if the waste weirs of most of the dams of to-day were calculated for a rainfall of 8 inches in 10 hours the majority of them would be found too small.

Another thing; the papers lay great stress on the fact that the pipes through the bottom dam were filled up. I have made no calculation myself, but Mr. Holbrook, Superintendent of the P. L. E. Railroad, informs me that he made a calculation of the amount of water these five pipes would carry off, and he found they would only have lowered the lake 1 inch an hour, so that with a rising of 10 inches an hour, that would not make much difference.

Chas. Davis: I visited the dam on the 11th inst., seven days ago, and noticed about the same conditions as Mr. Roberts has described. I paid some attention to the crest of the dam and to the waste weir. I measured out from the right bank. The length of dam is 900 feet. Next to right bank, or next to weir, there is a stretch of dam still standing 300 feet long, then a space covered by the washout of about 400 feet in length, then a further stretch

of dam of 200 feet, connecting with the left bank. The breach extends to bottom of dam and is some 50 feet wide there. The dam is about 70 feet high.

I went down into the weir and took some measurements and levels. (I had a hand level with me.) I found the bottom of the weir somewhat irregular, and finally concluded to take a timber sill connected with trestle bridge as a base, as representing the crest of weir.

Standing on that I took a sight to what I thought at that time would represent the crest of the dam, *i.e*, a sight on the top surface of road on crest of dam at the breach.

I made the level of crest of dam $4\frac{1}{2}$ feet above this sill. Before leaving waste way or weir I measured the width of opening under the bridge and found it to be about 105 feet; also measured it immediately below and found it 90 feet wide. I looked at the screen and made such measurements as I thought necessary.

I went into the weir also, to see if I could find any marks of the flood. At first I could not discover any. I thought I would see them on this timber trestle, but could not find them. Out in the weir itself I found marks on the shale banks and on the bushes, showing that the water was over 6 feet above the sill. It showed a 6 feet flow there instead of $4\frac{1}{2}$ as mentioned in some of the newspapers.

Now, after going over on the crest of dam and examining the ground closely, I found I was mistaken in taking the sight for level of crest of dam above weir; that there was a sag in the crest in both banks contiguous to the breach, this sag extending back along road or crest some 25 or 30 feet; that the water in pouring through the breach had saturated the ground for some distance in from face of breach, and, of course, the crest had dropped down. Looking at the ground carefully, near the break, I saw numerous cracks. I found there was a sag of some 6 inches there. The crest of the dam was in reality 5 feet and over above the sill in weir, instead of $4\frac{1}{2}$ feet. The top of dam next to weir was slightly elevated above other portions—say about 1 foot. This sill stands 8 inches above the floor of weir. On top of it is the screen, composed of vertical iron bars, $\frac{1}{2}$-inch round, spaced $1\frac{3}{8}$ inches

between centres and 18 inches high, connected by two horizontal bars $2\frac{1}{2}$ by $\frac{1}{2}$ inch. On top of that, for portion of length of screen, was a square piece of timber 8 inches square, with spikes driven in on the edges, making diagonals to the axis of the timber. These spikes projected out about 4 inches. This timber was probably a portion of boom which stood out in front of screen to keep the drift out of the weir. It was made to float, to rise and fall with the lake. The photograph of the weir as shown in the *Engineering News* is very good, but the obstructions are not as great as there represented. The point of view taken for picture tends to exaggerate the effect of the obstructions in the weir. The weir itself is at least 80 feet in length by 6 feet above the sill. This is the available cross-section. It is very different from anything I have noticed in the prints. It has been represented as much smaller. So far as the character of the work in the dam is concerned, it was much better than I expected to see. The dam was planned and executed by State engineers, and I think we should be very careful about criticising their work. (Mr. Davis then spoke of the puddle wall, describing it about the same as Mr. Roberts.)

Another point. In walking up the road to the dam, on the right bank of the stream, the bushes and tree-tops gave evidence by their inclination towards the dam, that when it gave away (half mile below being the narrows, and the stream making a sharp bend to the right) the water could not vent itself quick enough and had formed a whirlpool; the effect of this could be seen all along this road. The same thing took place at Johnstown when the stoppage occurred at the bridge.

After visiting the dam, as I could not get down again that night, I took the first train to the top of the mountains to Loretto. On my way I examined the Conemaugh very carefully, and found that there had been destructive washouts all along the line. Within 4 miles of the headwaters, at Lilly's Station, there had been 6 feet greater depth of water than had ever before been noted. The flood washed out the railroad here and submerged the coke ovens, or a portion of them at least. It was a very wild place all the way up and they had to run very carefully. At Loretto, the

gentleman with whom I stopped (Mr. Edward Glass), gave me his record of the rainfall, which was 5 inches in 24 hours. I saw the vessel in position in which he measured it, and do not think there can be any doubt about his measurement being correct.

I also took a Cambria county map found there, and calculated the water-shed of the South Fork valley above the dam, and roughly figured it at 60 square miles. I see it is given in this paper, *Engineering News*, as 55 square miles. The water-shed of the Conemaugh above South Fork Junction, I put at 70 square miles.

Mr. Davis then went on to give a description of the effect of the water from the dam down to Johnstown, which, not bearing on the question under discussion, is omitted here.

W. G. Wilkins: One or two more remarks I would like to make. In an article in the *Engineering News* a writer says that for forty years he kept a record of the number of dams that went out, and the proportion according to his record was one of earth, four of stone and ten or eleven, I have forgotten which, of timber crib dams.

T. P. Roberts: As Mr. McDowell is not here I will say that I had a conversation with him to-day. I asked him what his connection with this work was. He said he was merely invited to go up and see what could be done toward stopping a leak in the dam. They could not tell where the leak entered. He suggested that they get hay, manure and some brush with leaves on it and cover the slope as much as they could, on the place where they thought the leak might be, then dump clay on top of that, and that work closed the leak entirely. That was his sole connection with this dam, so far as I can understand.

There is one point I would like to call attention to. The average height of the flood-line to Johnstown is probably in the neighborhood of 30 feet. Of course there are some places above Johnstown where the water rose higher. Now, in watching the courses of flooded streams from the head waters, ordinarily the water begins to dwindle and lowers as it passes down the valleys, but in this case it seems to have maintained the same general height. I can account for it only in this way. Those streams were of unprecedented height. The Conemaugh was several feet

higher than ever before known, and the streams were over their banks in every direction. The valley was full from South Fork down to Johnstown. Now suppose that the velocity of this water was 9 miles per hour. When this current came out the velocity was something like 14 miles per hour, so that by gathering up water it kept its head. I do not know the exact time the waters struck Johnstown. I understand about 3.55 P.M. The time at South Fork was 3.08. But the time of the break of this dam no one seems to know exactly, although the consensus of opinions makes it just before 3 P.M. Now, from the time the water passed out of the dam until it reached Johnstown it had to pass over nearly 13 miles by the water-course. As soon as it reached the South Fork it ran up that stream and carried away the Pennsylvania Railroad bridge there, and here some of the water was temporarily stored. I can only account for the continued height that it was the waters already in the creek, caught up by the swift descent of the flood wave.

W. S. JARBOE: I heard of one clock in Kernsville which stopped at a quarter of four. Over in Johnstown, Walnut street, another stopped at six minutes of four, and I have seen several which all stopped at about six to eight minutes of four.

F. C. OSBORNE: Do you consider the workmanship good; that it was of first-class construction?

THOS. H. JOHNSON: In regard to the crest of the dam, I today saw a photograph of the dam, taken some time ago, from a point on the hill-side below, down stream, and at an elevation slightly above the crest of the dam, so that the crest was projected in a sharply defined line against the surface of the lake seen beyond it. The only evidence of a depression was a slight one near the centre of the dam, so slight as to be almost indiscernible in the photograph. Judging by comparison of the length of the depression to the length of the dam, I should say it was not over 150 feet long and exceedingly shallow, less than 1 foot.

T. P. ROBERTS: (Mr. Roberts here made a sketch of the section of the dam shown in the *Engineering News*, before referred to.)

The workmanship of what is left here is certainly excellent. I

do not know anything about the portion washed out. There is nothing remaining of it. You must recollect that this road here is of very compact material. There is no doubt that the dam was strong enough to resist any pressure up to its full height. The old part was certainly of excellent workmanship. It must be recollected that the old engineers of Pennsylvania had had a great deal of experience in the construction of these reservoirs. Mr. William E. Morris was the engineer in charge of its original construction. I have been looking up the records, but I think undoubtedly it was built on the plans of the other reservoirs. But it was never intended to overflow. It was much weakened by the reaction of the overfall which is always to be dreaded. We have on the dams on the Monongahela horizontal cuttings in the river bank where as much as twenty acres have washed out, caused by the reaction of the water.

W. G. Wilkins here read the article or that portion of it bearing on the question from the *Engineering News*.

In answer to a direct question as to what he considered the cause of the giving away of the dam,

T. P. Roberts said: No earthen dam ought to have water allowed to flow over it. The waste weir was not large enough to carry out the water. The exact dimensions and profile of it have not yet been fully determined.

Isaac Winn: It seems to me there has been a great deal of distrust about this dam for years. Why did the people distrust it? They had had warnings repeatedly, but seem to have paid no attention to them. There evidently was something wrong besides this overflow. It is true the water ought not to have been allowed to overflow, for it took away the dam rapidly.

I think there has been great neglect on the part of some one. This dam has been in bad condition for years. From the information we can get, the repairing was not done as well as the old work. With regard to this wicker-work at the weir, we all know it would have been an obstruction to a great extent and would impede the flow of the water somewhat. I know in my experience in mill-races we always had trouble of this kind, and in the spring more than in the fall.

L. S. CLARK: In regard to that boom I will say it was in the shape of a V and it was made to fall and rise with the lake, being fastened to the end timbers of the bridge. I think it was a good thing. I have been up there at all seasons and never saw brush or other obstructions in the net-work.

J. A. BRASHEAR ended the discussion by summarizing as follows:

The general consensus of opinion is that for this kind of a dam this one is about as good as could be made, but a critical analysis of the discussion here to-night seems to point to one thing, which might have been discussed further, and that is, that some provision should have been made for just such a thing as happened and which destroyed the dam; that is, that it should have had a larger out-flow than was possible with the weir or shoot in use.

It seems to me to settle down to this, that the dam was constructed well enough, if there had been an out-flow large enough to take out the excess water. But there was not sufficient drain for the tremendous flow of water from this "cloudburst;" if there had been a means of opening that outlet so as not to have an overflow, it would have been the solution of the whole matter.

Society adjourned about 10.45 o'clock P.M. to September 17th inst.

S. M. WICKERSHAM,
Secretary.

SEPTEMBER 17TH, 1889.

THE Society met at their rooms at 8 o'clock, P.M.

Present: John A. Brashear, President; W. L. Scaife, Vice-President; T. P. Roberts, Charles Davis, M. J. Becker, Directors, and 17 members.

The President announced the subject to be considered was the appointment of a committee to meet a committee of the American Society of Civil Engineers to discuss the proposition co-relative to forming one great engineering society.

The President read the documents received.

MAX J. BECKER opened the discussion by saying: I can add but very little to the circular. The American Society of Civil Engineers, which I think is now about thirty years old, was at the time of its organization virtually a local society, because at that time there was very little engineering talent scattered throughout the country at large, and the membership was almost entirely confined to New York and its immediate vicinity.

But the Society has grown. I think that it now numbers something like 1200 members, and especially has its membership developed largely throughout the Western States and the interior of the country. There have been for some years past wishes expressed, especially by the western members, to have the Constitution and By-Laws of the American Society revised. Just in what way the reforms were to be brought about was not definitely expressed by anybody, but a general desire appears to be felt towards a revision, and at the last annual convention, which was held in the month of June, at Seabright, a motion was made to the effect that a committee of seven members be appointed by the President to undertake a complete revision of the Constitution and the By-Laws. The resolution passed without any dissenting voice.

It devolved upon me as President of the Society to appoint the committee, and I selected Mr. William P. Shinn, whom you all know, as chairman of the committee. He was, by the way, the mover of the resolution. I also appointed Major Michaelis, who was at one time stationed here in charge of the United States Arsenal, and now located at Augusta, Maine; Mr. Mendescohen, of Baltimore, is a member. Mr. Strobel, who was at one time a member of this Society, now located at Chicago, is another. Mr. Collingwood, of New York, connected with the construction of the Brooklyn bridge; also Mr. Brush, of New York, and Mr. Whinery, of Cincinnati.

The By-Laws of the Society require that any amendment to the Constitution must be voted for by letter ballot, and of course they have to be sent out in November in order to be voted on finally, or accepted or rejected by final action at the annual meeting, which is held in January in New York, and this circular was

written for the purpose of urging action on the points mentioned in advance of that time.

The committee has had one meeting in New York, but they soon found that their scope of duties was so extended that they could not hope to bring the matter so far forward as to have it voted upon or even send out the draft of the new Constitution and By-Laws in November, and they have come to the conclusion that they will simply report progress at the November meeting, and ask to be continued beyond the January meeting, having their time extended to the annual convention which is generally held in the month of June. So that the urgency is not so great as might appear from the tone of the letter, which was written, I think, before the committee held its first meeting.

The present Constitution and By-Laws are rather ancient documents. They have been patched and overhauled, altered and amended to such an extent that there is really no proper order or system remaining. They are not in good shape, chronologically or otherwise, and the desire for revision is general throughout the Society. I think this committee will not merely amend it, but will rather throw the old document into the waste basket bodily and make a new one, to be submitted to the members for their adoption or rejection, because the old one can not be patched up any longer.

Now, one of the points upon which a majority of the members agree is that they are anxious to increase their membership, and as a means of doing that they think that by organizing chapters or branch societies throughout the country, the membership can be largely increased and the general usefulness of the Society promoted. It is for that purpose particularly that this circular has been addressed. Just how that project can be carried out it is difficult to foresee. No doubt there will be much discussion, and the views of the members throughout the country are asked for. I think it must strike any one as a move in the right direction. The present membership of the American Society is of such a standard that the older members particularly would feel perhaps some reluctance in having it lowered. I think they would be in favor of having it maintained, but at the same time they feel that

they should not exclude any one who feels an interest in engineering matters and who ought to have an opportunity of participating in a discussion of engineering subjects.

In order to do that they will probably propose grades of associates or a junior class so as to give everybody an opportunity of coming in. Now if this can be done in such a way as to absorb the local societies which are now scattered throughout the country, which would not necessarily have to lose their identity, but would simply change into auxiliary or branch societies of the American Society, every man would become a member of some grade in the American Society instead of as now being a member of a local organization. It would bring the different local societies in harmony among themselves; they would all be simply chapters of the same mother institution, so that there would be a close relationship existing between them all.

This is the sum and substance of the subject that is proposed in this circular and address. The appointment of a committee, if the Society should see proper to entertain the proposition, should, I think, be accompanied by some sort of expression by the Society itself as to whether the measure is a desirable one, so that the American Society might know, in a measure at least, as to whether their project is viewed favorably or not, because it may have a bearing upon their own deliberations in the matter.

The benefits which the members of the local societies would derive would be the papers and publications of the American Society, the use of their library, a nice place to go to in New York, and a general exchange of fellowship and good feeling among the members of the profession.

THOMAS P. ROBERTS: I met one of our members on the street yesterday, and he told me that Mr. Metcalf was interested in this question. That was the first I had heard of it. I then, as the only member of the Programme Committee in the city, wrote a letter urging him to come, as we had been unable to get any papers.

A great deal can be said touching this proposed affiliation. While it is probable that our Society, at first glance, might regard the scheme favorably, it is yet a little peculiar from the fact that prob-

ably one-half the membership are not professional engineers. That point was partly covered by Mr. Becker when he spoke of having the local societies as chapters, independent within certain limits. In that way it is possible non-professionals might have the benefit of the publications of the united organizations without being compelled to pay the present large dues of the older Society.

We might lose our name and identity, but I presume, of course, we would retain our library, and conduct our meetings much as we have done in the past. All these matters would be very proper for a committee to investigate and report upon. I am in favor of a movement of this kind if it can be shown that it will lead to closer fellowship and promote the interests of the profession.

M. J. Becker: I might add to what I have already said that the local Society of Cincinnati, and also the Society of Chicago, have addressed communications to the American Society of Civil Engineers, and expressed themselves very warmly in favor of some such movement. The Society of Cincinnati, consisting of the local members of the American Society, who have an organization of their own, have gone so far as to outline a certain way of bringing about this proposed arrangement; and while I do not fully recollect the details, I remember this much, that they would propose to divide the United States into districts. I think they suggested fifteen or eighteen districts. They would be outlined geographically, so as to remain adjacent and connected together, but the area would correspond to equal numbers of members in each district, so that the representations would be about equal. New York which, perhaps, would have three or four times the number of members within its own limits that there would be in any of the other districts, would simply represent three or four districts, whatever the number would be. Each one of the districts would be entitled to representation on the board. At present there are only five directors in the American Society, and, in order to transact their current business, three of them, under the Constitution, are compelled to be local members of the society, residing in New York. One of the two Vice-Presidents is, under the Constitution, compelled to reside in New York, and naturally the Secretary and Treasurer. Under these circumstances, some of the western people feel that

they have not a sufficient representation in the management of the affairs of the Society.

By the organization of these chapters, they think that proper representation and proper care of local interests will be obtained which they could not have under the present Constitution and By-Laws, so that the matter has been talked over and canvassed, I know, in Chicago, Cincinnati, Kansas City, and elsewhere.

Any committee that this Society might see proper to appoint for this purpose might be either instructed, or the wishes of the Society might be communicated to them, and they might be restrained in their actions and in their conferences with the American Society, so as to oblige them to report again, and, after the matter has been matured and about ready for consummation, it could be brought up here for our consideration before final action is taken.

J. W. LANGLEY: Some years ago there was an experiment tried in this country which has a little bearing on the present proposition. An attempt was made to start an American Society of Chemists, the headquarters of which were in New York. It grew out of the local society in New York. A proposition was made that all the chemists in the country should become members, and they were divided into two grades, those residing in New York or within fifty miles of it, and those outside of this limit.

The plan started off very well, but in a short time the membership fell off very rapidly, the outside members finding they were getting nothing for their subscription but the published minutes of the society, and they were only providing the means for promoting the interests of the New York members. While the society is still in existence, the membership has fallen off, and the society is not a national one in any sense.

On the other hand, at the recent meeting of the American Society for the Advancement of Science, held in Toronto, a resolution was introduced for the formation of another society. While no very definite action was taken at that time, I think it is quite probable that something will be done to form a National Society of Chemists. I am not in favor, however, of so merging this Engineering Society as to lose our individuality. We want to keep our own publications. If we should lose our individuality,

one of the principal motives for the continuance of the Society will be taken away, and we shall have no publications but those of the American Society. Would it not be possible to have an organization founded a little upon the plan of our nation; that is, that each society will keep its own individuality and its own publications if necessary, and be connected with a central society, very much as the States are, with a central representation at Washington?

R. N. Clark: What Prof. Langley has stated recalls my experience with the Society of Mining Engineers, which has, for one of its principles, that it should never have any central body. In that it differs entirely from the Civil Engineers. In my western life we had there little bodies of our own, little meetings of our own, very much like our present meeting to-night. We had papers and discussions, and in that we carried out the idea of not centralizing ourselves too much and losing our individuality, which, I think, is the great point here. If we are to lose our individuality, being controlled by them, reading only such papers as are suggested by them, governed by their rules, I should object to it; but if we, outside of the general line of work suggested by them, can control our individuality and at the same time become a chapter, we will do a great deal better than if absorbed by them.

W. L. Scaife: It seems hard, at present, to come to any final conclusion in regard to this matter, and I think it would be well, at any rate, to appoint a committee to confer with the other committee and report to our Society. There appears to be a general consensus of opinion that the American Society ought to increase its usefulness in some way, and that if the different engineering bodies in the country could be united in some way, the engineering progress of this country would be greatly increased.

The members will probably recall the fact that some time ago we received a communication from the Kansas City Engineers' Club asking us to appoint a committee to confer with them in regard to some means by which members could be transferred from one society to another. They may remember, also, that a report on the subject was made and adopted by this Society. I merely mention this to show that there are other means besides consolidation by which the members of different societies in the country may

be brought into closer relationship. As the subject is one that cannot be settled by any one society or in one evening, I think the best plan would be to have our committee appointed to meet and co-operate with the committee of the American Society, and to report to our Society, for acceptance or rejection, the result of their conference.

The President asked Charles Davis for his views. He replied that he coincided with Mr. Scaife and Mr. Langley, and thought that the subject was an important one and that a conference should be held.

M. J. Becker: I am afraid I failed to make this thing clear. I may have so expressed myself as to leave a doubt in the minds of the members as to what this thing means. What the committee of the American Society is trying to call out is an expression of the engineering fraternities of this country as to whether an affiliation of their members with the American Society was desirable. If they find the sentiment against it they will probably not incorporate anything of the sort in the new Constitution, but even if they do incorporate anything of that sort it does not follow that we are bound to be swallowed up by it. We can be just as independent as we are to-night. But it is simply courtesy in response to this invitation to let the American Society know whether we would favor anything of the kind or not. Now we can do nothing less than give them some sort of an answer. The only way to do is to find out among ourselves whether we want to join or not and let them know. That is all there is in it.

J. A. Brashear: I think Prof. Langley expressed a very pretty idea if carried out. I do not see why it could not be, if the American Society would receive us in that way. Now if the American Society would say that for a certain sum any local society could be represented and they would be willing to receive the representation in their annual meetings, we would also get their publications. It does seem to me that something could be done in that way. We could have our own local society as we have it now. That might be suggested to the committee.

T. P. Roberts: I think the American Society should have outlined some policy or plan so we would have their idea, instead

of asking the local societies for their opinions. The first intimations should come from the party that proposes to wed. We are waiting to be asked.

W. L. SCAIFE: As I said before I do not think we can settle the matter here. As I understand Mr. Shinn's circular, he wishes not only an expression of opinion, but that a committee should be appointed by each society to meet a similar committee from the parent society and talk the matter over. For that reason I think we should only appoint a committee to-night, and, after their report, we can go over the subject again for final action.

MR. SCAIFE offered the following resolution, which was unanimously adopted:

Resolved, That the chair appoint a committee of three (3) to confer with the committee of the American Society of Civil Engineers, and report to this Society the result of the conference.

The chair appointed on the committee W. L. Scaife, J. W. Langley, and Thomas P. Roberts.

J. W. LANGLEY, after conclusion of the discussion, stated that he wanted to ask informally a question. He stated that the Crescent steel works are supplied with water from the Allegheny river by a crib in the centre of the stream. That in January last, when the water was high and muddy, they noticed that the water from their tanks which went into the boilers was very clear, and on examination it was found that it did not come from the river at all. It was highly saturated with bi-carbonate of lime and was very much harder than the river water. It appeared to come from springs in the river, and he wanted to know if such a state of affairs was known before.

T. P. ROBERTS replied that in pumping out water from a coffer-dam at Lock No. 4, Monongahela river, a half acre was dredged out and water from several springs burst forth from the bottom which were perceptibly harder than the ordinary river water. It was perfectly transparent and seemed to carry traces of iron, rapidly oxidizing tin vessels. It was pleasant to drink and was very cold, about 56° Fahrenheit, if I remember rightly.

J. P. ROBERTS then went on to mention a theory advanced by

a gentleman some fifteen or twenty years ago for the improvement of western rivers by the use of submerged dams. He had noticed that there are a great many springs in the bottoms of rivers; that by excavating trenches, filling the same with some material impervious to water, selecting those places in the watercourses where these springs occur, the water would be kept at such a level that about 10 feet of navigation would be had all the year round. Unfortunately for this theory there are places where solid ledges of rock cross the water valleys, as at the Louisville Falls, and there is no apparent difference in the volume of water above the rock ledges and below.

R. N. CLARK: I would like to ask Prof. Langley if he knows of any analysis having been made of the waters of the Monongahela Water Company, which is obtained from submerged cribs.

J. W. LANGLEY: I have no information on the point.

J. A. BRASHEAR: I would like to ask if there has been any analyses made of the waters of the Allegheny and Monongahela rivers for the purpose of comparison. I have understood that there is much less lime deposit in the Monongahela than in the Allegheny.

T. P. ROBERTS: There is a difference in the analyses. Prof. Phillips has made a great many analyses of the water of both rivers. The Allegheny river water compares favorably with the best soft-water rivers in the West. The difference, however, between the two rivers, except in extremely low water, is very slight. There does not appear to be any permanent hardness in rivers that run a great distance. Antietam Creek, for instance, is very hard at its source, but at the mouth you can hardly distinguish it. The Allegheny river, I think, is almost perfectly soft water. There is certainly a greater percentage of mud in the Monongahela. In a very low stage, however, in the Monongahela the proportion of iron and sulphur water from coal mines is relatively so great that its waters below the mouth of the Youghiogheny become very perceptibly hard.

Mr. Roberts then went on to speak of a peculiarity of the Youghiogheny River, due to the fact that so much old mine water ran into it. Dams are sometimes constructed to hold back water

in abandoned diggings, and when these are let out all the fish for miles in the river are sometimes killed. The effect of sulphuric acid in the river is to combine with the free oxygen in its waters, which, after a certain limit is reached, asphyxiates the fish—and yet such fish found dead and floating belly up are gathered and eaten by the barbarian perpetrators of the outrage. However, the ordinary operations of coal-washing have doomed the Youghiogheny for fish. The advocates of the use of coagulents for clarifying water, at times have on this river a wholesale illustration of their plan. The waste from washers appears to turn the entire stream at McKeesport to a peculiar indigo-blue color, while, in recent years, it is observable, even at Lock No. 1, in the city, the bottom of the river can be discerned at a greater depth than formerly. It is also noticed that the iron-work about the gates corrodes more rapidly than it did in former years.

On one occasion I was standing on the Youghiogheny river bank, at a place three miles above McKeesport, and remarked that the river appeared to be very shallow, although I knew that steamboats went a short distance above this point. My reason for thinking it shallow was that I could see, as I supposed, the bottom plainly all the way across. A native of the place, in answer to a question, stated that the water was 16 feet deep. I could scarcely believe him, but just at the moment a tow-boat came along, and I knew the water was deep by her action.

What I took for brown-colored boulders in the stream was, in reality, flocculent, wavy masses of coagulated material, quiescent and suspended in the water a foot or more beneath the surface. The moment the boat had passed, I observed that the previously clear-looking stream had been churned up from shore to shore, presenting a brown and very turbid appearance. In the course of an hour or more the surface became clear again, exhibiting the same deceptive appearance. Ordinary sediment in our waters, without the aid of a coagulent, I am positive, would never have settled or acted as this water did. It is quite possible that there are periods during which the Youghiogheny river at McKeesport is unfit as a source of water-supply. I believe there is, as yet, no general complaint in regard to the water, though individ-

uals have stated to me that they thought it was occasionally very hard, but, being clear, others thought it was simply perfect. Clear water poisons vastly more people in this country than are killed with mud.

Adjourned at 9.30 o'clock.

S. M. WICKERSHAM,
Secretary.

OCTOBER 15TH, 1889.

SOCIETY met at their rooms at 8 o'clock P.M.

Present, President, J. A. Brashear; Vice-Presidents, W. L. Scaife, A. E. Hunt; Director, C. Davis and 52 members and visitors.

The minutes of September meeting were read and approved. The death of W. R. Jones was announced and, on motion, a committee, composed of Wm. Metcalf, A. E. Hunt and A. E. Frost was appointed to properly prepare an expression of the feelings of the Society on the occasion and report the same.

James O. Handy was duly elected a member.

Mr. Isaac S. McGiehan was introduced, and made the following statement on the subject of

STANDARD METAL TIE.

GENTLEMEN: I can assure you that I felt not only flattered but pleased to receive the invitation of your Vice-President to say a few words before such an assemblage of learned gentlemen, and it is not without some fear and hesitation that I shall proceed to say anything on the subject of metal ties. I am aware that there are times when it is comparatively easy to make an acceptable speech or address, and especially when the learning of the speaker and his command of language is not below the intelligence and comprehension of his audience. One can often blend words together and create sayings mirthful, witty or sarcastic, as the occasion may require; but when you stand up to discuss or treat upon an engineering problem before a body of engineers, I can assure you it is far more difficult.

Experience has taught me that on such occasions it is best to

rob the subject of its frills and feathers and get right down to hard meat and solid facts. I do not suppose that you gentlemen would care to have me read the statistics which I have gathered on the question of metal ties. You would not care to have me absorb so much of your valuable time, because it would take considerable, so I will just give you a few ideas on the subject as I have gathered them for myself.

I find that the first metal ties were used, as far back as 1860, on the Paris, Lyons and Mediterranean railway. Since that time they have been creeping in very gradually all over the European countries, until now, I may say in the words of Colonel Mulberry Sellers, there are millions in use. On the India Railway line there are over 1000 miles of track now laid on metal sleepers, and they have been adding to these constantly. I do not believe, however, so far as I can tell, that the tie which they have adopted is a perfect one, and yet the India railway runs the fastest and heaviest trains in India, and their immunity from accidents has become almost proverbial throughout the world.

At the International Railway Congress in Paris, which was held recently, a series of questions were prepared and sent to all the leading railway engineers throughout Europe, asking that they report upon the experience they had had with metal ties, and a great many of them rendered favorable reports. I may say all the reports that were rendered were favorable.

Among the reports rendered was one by Mr. Mayer, who was Chief Engineer of the Simplon railway of Switzerland. He reported that they had had them in use since 1863, and that up to the present time he had been gradually inserting them, until now he had 129,990 ties in use. The tie which he has adopted weighs 99 pounds and a fraction. It is made of homogeneous iron or soft steel with a resistance to a breaking strain of 60,000 pounds per square inch. He reports that they have adopted them as a standard, that the matter is no longer one of experiment, and that he is inserting from 15 to 19 miles annually.

What makes these statistics as coming from Mr. Mayer interesting, is the fact that the road is notorious for its steep grades and short curves. He gives the grades to be 121 feet per mile.

That is very great. He also gives the curvatures as 1100 feet. He says that he runs from 28 to 30 trains daily in each direction. That the speed on branches is in the neighborhood of 28 miles per hour. On the main line he runs 40 miles per hour. He gives the weight of his locomotives at, I think, 34 tons, or in the neighborhood of 6½ tons per wheel. These figures are taken from a few translations which I have here. I am sorry I have not this paper. He states that his rails are 65 pounds, 19 feet long. Since 1884, however, they have been making the rails 39 feet long, putting in 13 ties to each rail.

I find also, that in England, France, Germany, Holland, Belgium, Austria, Russia, Switzerland, Italy, Spain, Argentine Republic, Sweden, Denmark, Cape Colony, Egypt, Algeria, India, Japan, Queensland, New South Wales, Chili and Mexico, some of the leading railroads have adopted metal ties, so that there is no question, seemingly, of their success.

Another one of the engineers who reported at the meeting says that on a section of 12 miles the third year he had the ties down, his expense for maintenance was $869, against $1563 for the same section with wood ties during the same period at another time. Mr. Mayer also reports that with the amount of ties he had down, 129,990 in all, in the five years only 48 ties were removed because of breakage, while with the wooden ties on the same section and same number of years from 20,000 to 25,000 ties would have been removed and replaced with new ones, which certainly shows in favor of the metal tie.

The pattern used by Mr. Mayer is what is termed the "Helfe" system, which is very similar to the Post tie represented in the *Engineering and Mining Journal* for December 29th, except that he used a clamp and wedge instead of bolts, which the other system has.

I find out of 84 reports which came into the Paris Congress there was not one man out of the whole lot who had not tried or used metal ties, and endorsed them. The showing which you get from this would seem very much to favor the metal tie, and their adoption shows that they are more economic, safer; that they do not wear out so quick, cost less to maintain, and in a great many

ways they are advantageous, and if you consider the climatic conditions of the countries where these ties were used, which were certainly adverse to them, it seems to me their adoption here would be far more beneficial than there.

Another advantage which I would mention here with reference to the metal tie is the fact that in case of floods and washouts, the ties and road remain in pretty good condition and can be used afterwards without any degree of risk whatever, while with the wood tie they invariably float up, disorganize the road-bed, become out of line, and, as a rule, the road-bed has to be re-made, the ties re-tamped, and the rails re-laid, which is, of course, expensive and annoying.

I have gone well over the subject, conversed with a great many engineers, both foreign and American, and notwithstanding the great advantages shown, and the large numbers of them in use at present, I do not believe that they have yet got a tie which is perfect on the other side. I believe that the problem of a perfect metal tie remains yet to be solved by American engineers, and I believe that, with the help of Pittsburg and some of our friends, we can do it. The first form of tie, I may say, that was ever used was of a longitudinal character; that is, it ran along under the rail. The next form that was used was termed the "bowl" sleeper, which was like an inverted bowl, one under each rail, with a tie-rod in between each pair. At that time they did not use metal cross-ties, the engineers considering it unsafe from the fact that they were made of cast-iron, and they invariably broke in the centre, over the solid portion of the road-bed.

On the India State railway the first difficulty they found with the metal ties was their getting out of line. They would tilt down on one side and then on the other, and slide sideways. The first experiment they made was to use an inverted section with the ends bent down to prevent it from going sideways, but when the train would strike a curve, and exert its force on the outer rail, the ties under that rail would sink and the end on the other side would lift from its anchorage which it was intended to take, and consequently it would slide and they could not prevent it.

The next experiment they tried was to dig a trench in the

neighborhood of 1 foot or 18 inches wide right along in the centre of the road-bed between the ties, and remove that portion of the road-bed. The effect was that it worked admirably. The ties would remain in line perfectly. The foundation seemed to be perfect under each rail, so that the centre would not receive the force and swing of the train, and which was reduced to some extent. There was no breakage reported after that trench was dug and the maintenance was reduced by the plan.

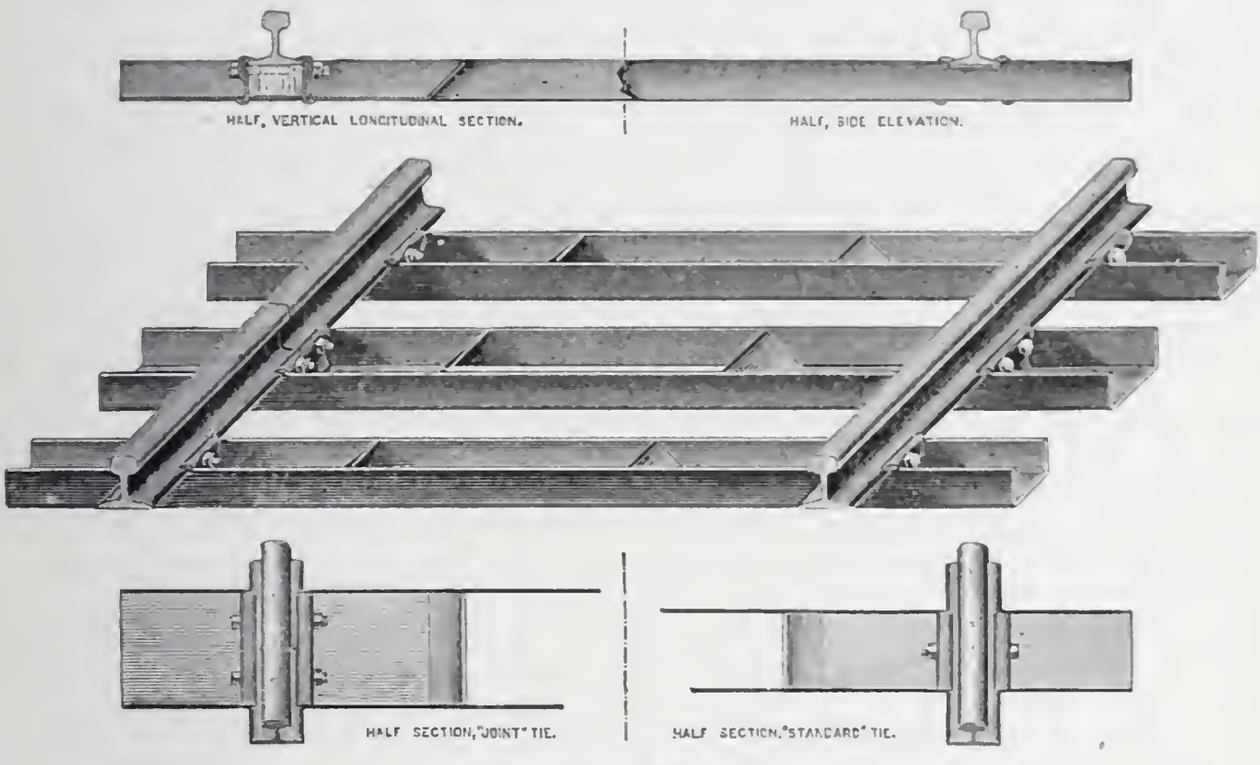
The only remaining defect of those ties was the effect of the metal contact between the tie and the rail, and it was impossible with that metal contact existing to make the fastenings rigid, so that all the parts became loose and they would rattle, making it both annoying and dangerous. And up to this time they have not found a method to destroy the metal contact or provide a fastening which was sufficient to hold the rails rigidly to the tie.

The metal ties which we have tried heretofore have been either importations from the other side, or imitations of some of their designs, and we have had precisely the same trouble that they have had. They will not stay in line, they are hard to tamp, and the fastenings are apt to get loose; also, the metal contact is bad. On the Pennsylvania railroad some experiments were made with the Webb pattern, which is an inverted section, with the sides slightly flaring; the rail clamps are riveted fast to the back and a wooden wedge on the one side to hold the rails. You could not keep them in line. They were very crooked, indeed. One day while I was looking at these ties there was an old Irishman standing alongside of me with a very disgusted look on his face, and I asked him what he thought of it. "Well, sir," said he, "since you have asked me I will tell you. It just looks like the front rank of Casey's brigade; one end's out and t'other is in and, be jabers, it's crooked from ind to ind."

The cost of the Webb tie in the United States would be rather prohibitory to its adoption, because it is very heavy. They have never been made of the light section, except for experimental purposes, and then it bent. I believe that for a metal tie to be acceptable in the United States, where wood is seemingly so plenty, it must possess some practical features. I believe that the centre of

the tie must either be removed, as in ours, or otherwise the centre should be arched, so that the tie spans that solid portion of the road-bed, and so that the foundation is directly under the rail, and not in the centre; I believe it should be a tie that could be easily tamped, and then, I think, the fastenings should be near where the metal contact is broken, and where the tie and the rail are held rigidly together, with no possibility of loosening or the parts becoming disorganized.

Then another feature, which is not the least one of the lot, a



The Standard Metal Tie.

metal tie to be acceptable here must be cheap. We cannot make a metal tie for our use the same as in foreign countries, regardless of cost, because we have a supply of wood which they have not. The principal features are those of safety, speed and durability there, to which, for our use, we must add cheapness. Of course, the paramount cost of any metal tie you would put down is bound to be more than that of wood, at the present price of metal. If we consider cost only, however, we would never make any progress. We have gone on building large coaches, heavy locomotives, and running faster trains than we ever did before, and yet we have

made no improvements whatever for those engines and cars to run on, or paid any consideration to the road-bed, except that we lay a heavier rail. The wood ties are not even so heavy as they used to be, and not so long.

The reduction of the difference in cost, I should add, with the press here, thanks to one of your members, Mr. Aiken, who designed it, is such that we can now produce a tie which is within the means of all railroad people. The difference in cost between this metal tie and the present wood tie is just the difference between the cost of stone and gravel ballast, so that if the railroads can afford to put down stone ballast and try to preserve the ties, they can spend the same money and put down the steel ties, and they would not need the stone.

The tie which you have seen here is worthy of my explaining a few of its features. The central portion is cut out to prevent the tie from slipping, and in the centre the resisting plates are turned up, so as to stand as nearly as possible against the central line of solidity in a transverse direction, and consequently they take resistance against the solid portion of the road-bed, and the tie will stand in line perfectly. Then the fastening is made with these two clips that hook to the bottom of the tie and slide over the rail-base.

The wood, which first is treated so as to render it indestructible, is held in place by the clip at the bottom, and on the top by the rail, and can never get out or become loose. If there should be wear on it, there is room left on the side to take it up, but I hardly believe there will be wear, for if it shrinks side-ways the clip will follow it up, and it will never shrink end-ways. We made some tests to ascertain its resistance. On the Pennsylvania railroad they put 101 tons on top of it, which was all the press would stand, and could not fracture the block. We put 27 tons on a tie supposed to support the same weight, and it was sufficient to destroy it. I believe with that fastening, and with the bolt that goes through here to hold it together, we can get a pressure to hold the rail down on top of the block anywhere from 5 to 10 tons, so that when your rails are all in line the ties and rails form a structure, and one supports the other. I think we get a uniform elasticity,

because when any portion of the structure sinks it carries its neighbor with it, as they are all joined together. The wood acts as a cushion, the rails do not touch the tie, and there is no metal contact, and I cannot see where there will be any objection.

Then it is proposed to dispense with the use of fish-plates. As you all know, the fish-plates are so placed as to take the weight of its load off the rail. Its opposition to the weight is at an angle, it being placed under its head, and then it takes its support from the base of the rail, being squeezed in between the two. Of course, the bolt-holes in the rail are larger than is necessary for the bolts to pass through, in order to compensate for the contraction and expansion of the rails, so that the only support the fish-plate has is simply its close fit in that small space between the head and base of the rail. Consequently, when a wheel goes over it there is an instantaneous movement from the end of one rail to the end of the other. This may be incorrect to some extent, and yet you may say it is almost instantaneous, because you cannot tell when it leaves one until it touches the other, so that at one moment you will have a pressure on the one rail corresponding to the weight of the wheel and its load, and immediately it is transferred to the other, so that as one rail goes down the other comes up, and it is a tremendous reciprocating strain which has a tendency to break the fish-plates. I have counted in one section of road, from Menlo Park to Metuchen, 74 fish-plates on the main line that were broken. That is only about $2\frac{1}{2}$ miles. I afterwards talked with the engineer of the road, who told me that it was impossible to make and put down fish-plates fast enough. The surface which the fish-plates have opposed to the load is, I think, $24\frac{1}{2}$ square inches under the head of the rail, while with this tie, from its side to the end of the rail, we get a surface of $29\frac{1}{2}$ inches, directly opposed to the load; then the clamp comes over the top of it, holding it down.

When you take into consideration the weight of our locomotives and trains, and the speed at which they travel, and especially if you have read in the papers of the recent accidents, like that occurring on the Pennsylvania railway at Rahway, by the spreading of a rail, causing the whole train to go over, I think you will agree with me that it is really dangerous to continue the use of wood

ties and imperfect spike fastenings, while we are still increasing the speed of the trains. I think you will agree with me that it is time for the railroads to take up the metal tie, or something which will add to the better service of our rails. I presume metal is the coming thing for it. I do not know of anything else.

Now, I have already taken up a great deal of your time; more than I intended to. In fact, I did not intend to say half as much as I did, and I ought to apologize for keeping you, but I want to say before stopping that I have been more than pleased to meet an audience of gentlemen like this; and with all the gentlemen I have met in Pittsburg. I find that a great many of our best firms come from New York to Pittsburg to get not only engineering ability, but to promote their schemes, which are only, you might say, in a primitive way contrived in New York.

And now, if you will pardon me, I will close something after the manner in which a friend of mine said of Mr. Oliver Ditson. He dressed in a clerical fashion, and while visiting some friends he was called upon to say grace. He complied. He got up and said a great many things, but during his saying of them he forgot to say "Amen." He could not think of the word to save his neck. He tried every way; he got embarrassed, and finally, in desperation, he said: "Yours Truly, Oliver Ditson," and sat down.

Discussion of Isaac S. McGiehan's Remarks.

A. E. Hunt: Mr. McGiehan has undoubtedly paid a great deal of attention to this, but I would like to ask this question: What do you consider the essential points of difference between the metal and wooden ties which causes this extra amount of creeping in the metal ties, and what precautions are yon now taking to avoid it more than what you have stated, to correct the differences between the metal and the wooden ties? The metal tie is smoother; there is less friction.

I. S. McGiehan: From the fact that the wooden tie is soft on its outer surface, and that stones and other articles stick to it, it becomes so rough that it cannot slide. On the metal tie the surface is smooth, and we must devise some artificial means to pre-

vent the creeping. All of the devices created heretofore to prevent them from creeping or going side-ways have been to spoon the ends down; then they found they would tip down on one side. The road-bed is always soft at the outside; at least as the railway people tell us they are constantly tamping at the outside it must be the softest at that point and more solid in the centre. If it is more solid in the centre the metal tie will break there more easily. The more it tips the more strain it receives, and consequently slides more.

If you get a ball started it will run down hill very fast. If you prevent it from starting it will stay where it is. The idea is that the wood tie does not start to slide, while the metal tie will slide excessively if it starts at all. To prevent that you must remove, in some way, the central portion, which is more solid than the outside portion. The rise and fall of the ends may not always be so perceptible to the eye. But I have laid on my stomach on the side of the track and watched the ties move, and I never once found that both ties sunk alike; one side would sink more than another, and it would be found that there was a round portion to the road-bed on which these ties rested. If you can get a perfect line under each rail nothing will disturb it, because you understand that it is the oscillating force of the train which creates the disturbance in the track. At curves it is greater than on the straight track. Railroad men will say they get no such force on a straight track, but they do.

H. D. Hibbard: What kind of wood is used?

I. S. McGiehan: It is an oak block.

H. D. Hibbard: How are they preserved?

I. S. McGiehan: Those we have been using are dipped in creosote oil, but it is intended hereafter to put them in a vat containing oil and force the oil in with pressure, so that every particle and crevice will be filled with the oil. I do not think it will decay. In the matter of cost these will be very cheap. We can supply them at two and a quarter cents each, and you see from the construction of the tie how easily they can be replaced.

H. D. Hibbard: How do you prevent the tie from rusting in contact with the wet ground?

I. S. McGiehan: At present we paint with tar.

Emil Swensson: What will prevent water from standing in the tie?

I. S. McGiehan: There are four holes in the bottom of the tie which will enable the water to run right out. In the winter-time the water will freeze, and will thereby add to its weight and become very solid; in summer-time the water will sink into the ground.

H. D. Hibbard: It seems to me that the question of cost, which has not been given a great deal of attention, will have a great deal to do with the introduction of this tie. I presume it costs not less than five times as much as the wooden tie. I understand that in Europe wood is scarce and used for very few purposes; but this objection does not apply here, and the cost will prevent the metal tie being used. It is a question to me whether the conditions in this country have yet reached the point where metal ties are to be introduced. I would like to ask if any have been sold yet.

I. S. McGiehan: I will say, in answer to that, that we have several orders which we have been unable to fill for the simple reason that we saw it was necessary to make the tie at the lowest possible cost for the railroad people. With the assistance of Mr. Aikin, who designed our press, we got up a very nice machine. It makes them very rapidly, and the cost of labor is reduced to very little, and will still go lower. In comparison with wooden ties, you will probably be astonished that it is only 29½ per cent. more per mile of track than the cost of the common wood tie of to-day.

H. D. Hibbard: Do you mean that you can furnish these at $2.25 each? How do you make, then, with wooden ties at about 84 cents, the cost of steel but 29 per cent. more?

I. S. McGiehan: We do not put in so many. In the next place there are no spikes and no fish-plates. As to the cost of wood ties, the Pennsylvania railroad paid, for first-class ties, 70 cents in 1884, and are paying at least 20 per cent more now.

H. D. Hibbard: Is not that delivered?

I. S. McGiehan: No, sir; that is f. o. b. I took the cost from their books. I do not mean saplings, but ties such as the

Pennsylvania would use. Then you must consider the wear. The average life of a wooden tie is in the neighborhood of five years, while the average life of this tie will probably be forty; so that you see the first cost, while more expensive, than wood, will, in the long run, be much cheaper. The Pennsylvania railroad tried metal ties at one time, but because they went sideways they threw them out.

MEMBER: What is the weight of this tie?

I. S. MCGIEHAN: This tie will weigh, I think, in the neighborhood of 69 or 70 pounds.

MR. DAVISON: I have been surprised at the figures you give for the cost of the tie. It is higher than some experience I have had, but you will probably be able to regulate that matter. I think you have failed to mention, in explaining the resistance of wooden ties to the lateral motion, that it is very largely due to the fact that probably 50 per cent. of the wooden ties are not straight. They are crooked, and have projections which add, I think, very largely to the resistance to the lateral motion.

I. S. MCGIEHAN: From first observation that would seem very true, and it is no doubt correct to a great extent. But I have seen miles of road built with ties that were sawed positively square and yet they did not slide sideways.

A. E. HUNT: I believe in what you say that the metal tie is the tie of the future, and it seems to me that a step is made in the right direction here in reversing the channel or sleeper itself. I think you are on the right track; at the same time it does not seem to me that you have quite answered the point which I asked about first, as to what was the difference, and how do you correct these differences, between the wooden and metal ties. The thought occurred to me that you could make a comparison, ascertain where the wooden tie has advantages over the metal, and then try to correct those disadvantages in the metal tie; that, perhaps, would give you an idea on which you could work. It seems to me that the wooden tie is solid in the centre. You failed to show why the rigid metal tie should be cut out in the centre. It seems to me that is not the objection. Would it not be possible to put their weight or greater weight at the ends of the metal tie, or

put on projections to prevent them from creeping? Perhaps these would have the same effect as extraneous substances on the timber tie.

I. S. McGIEHAN: I think, in the body of my address, I described the way they do on the India railway, where they had trouble in the tie sliding side-ways. When they dug the trench in the centre this was prevented, since they removed the central foundations so that the weight of the rail rests on an independent foundation on each side of the centre. We do not propose to dig a trench, but we take out the centre of the tie, which we think, is practically the same thing. Another thing I want to call your attention to, is that some of the ties used on the other side are in connection with the English bull-head rail, and you have none of the broad flange which we have here. They must line up their track after the rails are in position, while here the track is comparatively straight at first.

W. THAW: What road was that of Mr. Mayer in Switzerland?

I. S. McGIEHAN: The Simplon railway, I believe they call it. I got the translation from the *Revue Industrielle*, which was received the day I left New York.

H. D. HIBBARD: What material is this tie made of?

I. S. McGIEHAN: Soft steel.

MR. VERNER: I suppose that trains will get off the track even with this tie, and one serious objection to that tie would be the trouble of replacing it in getting the ballast from the tie. It would hardly be enough of a cushion, as the wooden tie forms in such cases. How will you get over that objection?

I. S. McGIEHAN: The train will, of course, cut into the tie, but ordinarily there will not be sufficient damage but what the tie can be easily repaired and replaced in the track.

The Society then took a recess to examine the sample tie shown by Mr. McGiehan.

After which the Society adjourned at 10 P.M.

S. M. WICKERSHAM,
Secretary.

NOVEMBER 19TH, 1889.

SOCIETY met at the rooms at 8 o'clock P.M.

Present, President J. A. Brashear, Vice-President W. L. Scaife; Directors Chas. Davis and T. P. Roberts, and 20 members and visitors.

The following-named persons were balloted for and elected members of this Society, viz: W. A. Cornelius, Hazelwood, Pittsburg, Pa.; W. G. Bell, Brick Manufacturer, P. O. Box 976; J. J. E. Wolffe, Keystone Bridge Works; C. H. William Ruhe, 102 Bluff Street.

The President appointed the following Committee on Nomination to report candidates for the various offices to be filled at the January meeting: Wm. Thaw, Jr., *Chairman;* H. D. Hibbard and F. C. Phillips.

After which Arthur Kirk read a paper on the "Use of Dynamite in Breaking Up the Jam at Johnstown," viz.:

REMOVING THE DRIFT JAM AT JOHNSTOWN, PA.

PITTSBURG, PA., November 19, 1889.

TO THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Gentlemen: When I arrived at Johnstown, Pa., about noon, June 1, 1889, it presented one of the most appalling and unprecedented scenes the eye of man has ever looked upon. The great outpouring of water from the precipitous mountain sides of Somerset county had filled the beds of all streams to overflowing height never before seen in that region, and as it had been customary for years for every one who wished to encroach on the bed of the streams, the Conemaugh had been so contracted that just at the lower end of Johnstown there was not space for this great quantity of water to pass, and a great portion of Johnstown was flooded to from 5 to 10 feet deep; for instance, one man, called McConnaughy, had stealthily encroached on the bed of the Conemaugh until he had sixteen tenement houses standing on ground properly belonging to the bed of the river. These sixteen houses were among the first to go, and formed the nucleus of the jam against the stone bridge at the lower edge of Johnstown. And

I may here remark, there seems to have been Divine retribution in the fact that Mr. McConnaughy was lost with his sixteen houses, and his body never found.

This was the condition when the great avalanche of water, 30 to 40 feet high and 500 feet wide (from the broken South Fork dam some 11 miles distant), rolled across the business portion of Johnstown, bearing on its crest every floatable thing that it had gathered from the 11 miles of narrow river bottom it had travelled, and much unfloatable matter under ordinary circumstances was swept along at a furious rate as if it had been feathers; for instance, a car loaded with pig-iron which with its load must have weighed not less than 60 tons, had been borne along not less than a quarter of a mile when it struck, and in one moment demolished, two fine 13-inch wall brick-houses (built together), and swept its Mansard roof away in a moment across the sites of less substantial houses that had gone before it with the wave. These were all hurled with tremendous force against a steep hillside, and houses, furniture, feather-beds and grindstones, pianos, stables, heavy railroad iron bridges and railroad tracks all broken and mixed up, with (estimated) from 3000 to 5000 human beings, of all ages and sexes, struggling in the seething mass. The wave thus loaded dashed so furiously against the mountain side that it recoiled and dashed against the Pennsylvania railroad stone bridge, about one-third of a mile below, consisting of 7 spans, of about 75 feet each, of massive masonry. This acted like a huge strainer, letting the water pour through it, but arresting railroad cars, loaded or empty, huge trees, some of them (estimated) 5 feet across the stump and 80 to 100 feet long, with roots and branches all attached. This soon collected débris and formed a solid dam across the whole 7 spans of the Pennsylvania Railroad stone bridge, and the water for a short time rushed 2 or 3 feet deep across the top of the stone bridge. Here was formed what is known as the Johnstown Drift, the like of which was never seen in the world. The heavy articles soon sank, taking with them the lighter, and the water, checked in its mad career, stopped and deposited its burden of thousands of tons of sharp sand and plaster, gravel, etc., to fill up the intricacies and solidify the mass, which I afterwards measured and

found to be 350 feet wide, 800 feet long up stream from the Pennsylvania railroad bridge, and apparently of an average depth of 20 feet. Many places near the middle of the stream must have been near 40 feet deep, and before I describe its removal I should mention that the whole mass near the stone bridge appeared to be interwoven with hundreds of miles of telegraph wire, telephone and heavy electric copper wire, all of which gave us much trouble from its being rolled up and interwoven in every conceivable manner; all through the mass another great cause of trouble was fine roots of trees interwoven in the mass of débris. I never before had any idea of the length and strength of tree roots. Permit me here to remind you that the whole 11 miles the South Fork wave had traversed before it came to Johnstown lay along a mountain gap and was an almost unbroken forest of healthy growing trees, whose branches often met across streams, and thick mats of laurel, and every tree and shrub known to such places, with scarcely one acre of cleared cultivated land on the whole 11 miles. The wave traversed all this mass of forest growth, suddenly tore out root and branch, earth and all, by the acre, as if they had been stubble, and their roots, being washed and cleaned of bark and earth, had become entwisted and entangled around among logs, demolished houses, etc. This also added to the difficulty of removing the drift, for we would find what appeared to be the top of a small sapling just sticking up near enough to the surface of the water to stop the floating drift and give trouble; then two or three men would take hold of it and pull at it, but all to no good; then as many as could would take hold of it, still no good. We one day connected a full sized Pennsylvania railroad locomotive to one of this description, working a 2½ inch cable over a snatch block, and the locomotive pulled and pulled at it until it pulled some 30 feet of tall young birch or willow tree (we could not tell which, for every particle of bark had been ground off it), then came its multitude of small roots, all entangled in a large mattress of telegraph wire, and after spending more than an hour with a locomotive and 10 men of a wrecking crew, and drawing a 2½ inch cable to almost its snapping point, we were forced to lower it down and leave it in the water, for we had no way of getting at it to chop off the roots,

and it was hugging the stone bridge so close we durst not dynamite it for fear of injuring the bridge. I may here remark, that I was forced to take great notice of these tree roots as they had been torn out and washed clean in many instances without being broken, until they branched off and off, still becoming smaller, often not thicker than a knitting needle, and I am much inclined to believe that the length of tree roots approximate the height of the tree while growing.

Strength of Tree Roots

of the willow and birch families appeared to be of the same textile strength as iron rods of the same diameter.

The Hunting for Valuables

by my men was another source of great trouble. I kept a crew of from eight to twelve men constantly employed making charges or carrying down and placing them in position, arranging wire, etc., and, although I allowed them one dollar per day more than was customary for other work, yet a week or ten days was as long as I could keep a man; then I would have to take on a new hand and teach him again. My work naturally took them much over the drift, and they would sojer off and hunt for valuables whenever an opportunity presented itself, and whenever they could get their pay they must go home, and would be seen going to take a train with a mule-pack load of valuables they had found among the drift.

Reasons why all these Difficulties are Mentioned.

I have thus been led to enumerate some of the difficulties in the way of removing the drift at Johnstown, because I have found a great many men who never were at Johnstown, and never saw anything approach it, and yet really thought they could have removed it in one-fourth the time it took, and done it better. I think they were honestly led to think thus because they did not know the great difficulties we had to contend against. I think my description of a portion of the difficulties must convince you all that no such combination ever existed in the world before; and this remark will apply to everything else connected with the Johns-

town flood. For instance, as soon as I had made an observation, and decided on a plan, I went to find General Hastings, who was said to have full charge of all matters. I found him in his head-quarters, just established in the railroad tower, standing on its steps surrounded by at least twenty men all eager to lay their cases before him; mostly men like Mr. Eisenberg, from Williamsburg, who had spent one day and two nights guiding five wagon-loads of provisions over the mountain from Williamsburg, and all anxious to have General Hastings order what to do. Some of these men had been hunting General Hastings for hours, and, of course, were out of humor; but General Hastings' calm, cool manner, with soothing voice, and his quick dispatch of business, soon allayed all bad humor and did great and invaluable services there. This necessary chaotic state gave great trouble.

Beginning Operations with Dynamite.

The large drift-raft I have already in a brief way described, had contained hundreds of wooden dwelling-houses, and much light burnable material, which had caught fire on Friday evening and had burned down to water surface, for, although the water at first ran over the stone bridge, yet it soon scoured out a channel through the shale rock in the bottom of the river, and was, by this time, rushing out under the drift and had left the drift a compact dam, as I said before, 350 feet wide across stream, and 800 feet up stream from the stone bridge, ranging in thickness from 20 to 40 feet, which had by this time been all burned over down to what had been water-level before; the water cut its way through under the mass, and

How to Remove what was Left

was the question to be solved. After carefully surveying the situation, I applied to Mr. Plum, Assistant Superintendent of the Pennsylvania railroad, for authority to act. He referred me to General Hastings, who, after talking the matter over, said it was very important to have the drift removed for several reasons; among other reasons, to get the thousands of dead bodies out that were supposed to be in the drift and keep them from contaminating

the water in the stream. He at once gave me full authority to do anything I could to clear the stream, but could give no tools of any description to work with, and as all the hardware stores in Johnstown had been swept away none could be bought there. I at once telegraphed to my office in Pittsburg for an assistant, a blasting outfit, and 100 pounds of dynamite; but how to get the dynamite to Johnstown was a question, for orders had been given to receive no freight for Johnstown. Application was made to Robert Pitcairn, Superintendent of the Pennsylvania railroad, who at once gave an open order for all I wanted for removing the drift at Johnstown should have best dispatch by first train, and my assistant and supplies were at Johnstown by daylight next morning; and I should here thank Mr. Robert Pitcairn, that all the time I worked on the drift all the dynamite and supplies I needed came through with the utmost dispatch, without any charges, which gave me great assistance and encouragement. I at once commenced to use dynamite in blasting near the stone bridge, as this was the lowest end of the drift, and the water was by this time running out very strong from under the drift, and I saw it would easily carry away any floatable material I could liberate. As I had to commence blasting close to the stone piers, I at first used charges of 5 pounds each; these I found I could use, and this amount within a few feet of the stone-work and do no harm. Then, as opportunity offered, I increased the charges to 10 pounds of dynamite, and fired 3 to 6 shots simultaneously by using an electric apparatus and exploding fuse in each bundle. I often had nails driven half through a piece of flooring board to keep the cartridges from slipping off the board, and had four cartridges tied on each side of the board by twine at each end of cartridge, then four more on each side, then four more, making a torpedo of 24 cartridges, or 12 pounds, tied on to a piece of flooring board with two electric exploders, one in each end of the charge; then, by pushing the charge or torpedo down between the logs I could sometimes get it 6 to 10 feet under water; then by placing a line of 6 to 8 of these within co-operating distance, say 10 to 20 feet apart, and firing all simultaneously by means of a battery, each torpedo, if placed close to a large strong log, would cut it off in sections, and it, with its superin-

cumbent weight, would be hurled in the air often 50 feet, and the lighter articles often 100 feet. A column of water often 20 by 100 feet would be thrown 100 feet in the air and fall back in heavy rain; this had the effect of shaking all loose. Of course, the heavy articles returned earthward first and sank; the lighter articles would float off down stream.

Of Making a Sausage Torpedo.

Again, I had water-tight gum tubing 2-inch diameter; when I wanted to cut off the end of a railroad car-bed I would make a long sausage-like torpedo by putting, say 20 dynamite cartridges in, one after another, putting an electric exploder in last cartridge at each end, tie both ends like a long stretch of Bologna sausage, then lay this along where it was desired to make a cut and cover it with mud, and when fired it would cut through the oak timbers and irons of a railroad car, the same as if they had been so much pasteboard.

Of a Bag-Torpedo.

One day I found a large mass to be shaken up, with fine chance for a blast, away down some 10 feet, but the only chance to get a torpedo down to the right place was between two large logs fast in the drift, and not quite 3 inches apart. While planning what to do I happened to disturb some white rags at my feet; picking it up I found it to be a fine, strong pillow-slip; dropping the closed end down between the logs, I made a man hold the pillow-slip open until I dropped eighty (80) dynamite cartridges down lengthways between the logs into the pillow-slip, then two exploders, and tied the mouth of the pillow-slip together, attached a rope and lowered the torpedo away down, guiding it to the desired place, and fired it with very satisfactory results.

Of a Box-Torpedo.

A great deal of our blasting was done by means of a box-torpedo. To prepare these we opened a 50-pound box (dynamite is always shipped in 50-pound boxes) and took out 15 pounds, leaving 35 pounds, then placed two exploders in it and filled the box with sand

or gravel to keep the cartridges altogether when lowered in the water, and nailed on the cover again ; then by means of a small rope lowered it down in the water to desired place.

Of Blasting Logs.

It often happened that a large log with gnarled matted stump would project from the drift so that it must be dealt with alone. In that case, if the stump was chopped off and dropped into the water it would have lain still there, obstructing the water-passage, same as a large rock would have done. In such a case I had sometimes as high as 35 $1\frac{1}{2}$-inch holes bored 10 inches deep, and a $\frac{1}{2}$-pound dynamite cartridge, with exploder attached, put into each, tamped with sharp sand and all fired at once, and this would often crush stumps to stove-wood size, and this would float off gently without further trouble. I should also mention the razing to the ground of a

Roman Catholic Church by Dynamite.

On the first Sabbath day after the flood Thomas McAnnalie, an employee of Booth & Flinn had it prepared for blasting. It had been a fine brick building, perhaps 70 x 100 feet, and of the usual height, with high brick steeple in front. The brick-work was still standing, perhaps 125 feet high, and the walls were still standing, but as every vestige of wood had been burned out of it on the first day of the flood, and its burning had no doubt lessened the strength of the common brick walls and they might fall at any moment, and as it stood on the edge of the track of the wave where thousands of people were passing every day, it was decided late on Saturday to blast it down, and by noon on Sabbath 25 holes had been drilled into the brick walls at proper intervals. Every person was cleared away for a space of 200 feet around, and the charges fired simultaneously. A belt about 1 foot wide and about 2 feet from the ground was pulverized and blown out, and the whole building and the pinnacles of the steeple and the walls gave a shiver and quickly melted down in an indistinguishable mass of brick, very few of them broken by the fall, and I would here recommend this same

PLAN FOR REMOVING DANGEROUS WALLS OR CHIMNEYS

left standing after a fire, because the dynamite merely crushes it, and the wall instantly drops without falling out, and the bricks and stone trimmings are left in far better condition than they would have been by any other plan of removal, but the grandest sight of all was the firing of

FOUR HUNDRED AND FIFTY POUNDS

of dynamite in the drift at one time on the second Saturday after the flood. During these two weeks we had a constant swarm of newspaper reporters, representing every prominent newspaper in the country, who, on account of its novelty, naturally gave minute accounts of the drift and everything connected with it, and the country became alarmed, especially the cities such as Pittsburg, and as far as Cincinnati, who had no other water-supply than river water. Naturally, we were anxious to know that the drift and the dead bodies it was supposed to contain had been removed. During these two weeks everything had been done that men and money could do to expedite the removal of the drift. Ex-Governor Bigler had recommended them sending for 300 experienced loggers from his district in Clearfield county, who, he assured General Hastings, would clean it up in forty-eight hours, and they had been sent for and had come equipped with best cant hooks and pike poles, and after two days' trial had gone home disgusted with the job.

Then a young man, a Mr. Osborn from Altoona, with great pomp and profanity, assured General Hastings it was all nonsense to waste time removing the drift by dynamite, that he had a gang of men that could clean the whole thing up in a short time. General Hastings, being anxious to have it removed, gave him the job, and told me to stop the use of dynamite, as Mr. Osborn would remove the drift far quicker. I then put my apparatus and tools in storeroom and went to bed for much-needed sleep, and in less than twenty-four hours a message from General Hastings directed me to resume the use of dynamite, as Mr. Osborn had given up the job. These were the conditions when, toward the close of the

second week after the flood, Governor Foraker, of Ohio, telegraphed to Governor Beaver, and Governor Beaver forwarded the message to General Hastings, urging that everything be done to remove the drift and its dead bodies. General Hastings and Colonel Douglass came to me on the drift, and, after consulting with them, it was decided to try a large blast. Up to this time we had directed our attention to cutting a canal, about 100 feet wide, up through the centre of the drift, and got to about 150 feet from the mouth of the Conemaugh Creek, which joins the Conemaugh river; this was about 600 feet from the stone bridge, and as there were no houses near to be injured by it, we prepared nine boxes, each containing 50 pounds of dynamite with 2 exploders in each box, and 25 to 35 feet apart; 3 across the breast of the drift at head of canal, and 3 across it about 35 feet back, and 3 more about 30 feet back of that again, and sunk all as deep as we could get them, from 4 to 6 feet under water, and fired all at once with the battery. The result was grand beyond description. Large saw logs and railroad ties and such like were tossed at least 100 feet in the air as if they had been chips; lighter articles were carried with the tremendous volume of water some 200 feet high. The river must have been drained to its bottom for at least 100 feet square to form the column that went up so high, and when it returned with its load of logs, etc., it produced a wavering motion in the water of the river which lasted a minute or more and shook the drift loose by the acre, which gradually drifted down, cleared it up to the junction of Stony Creek, and within a half-hour Governor Beaver was notified, and through him Governor Foraker, of Ohio, was notified that the Johnstown drift was opened through. It took several weeks after this to clear up the shores, as the water soon after this lowered rapidly, which added greatly to the trouble and expense of removing the drift-wood.

In conclusion, permit me to say, I fully believe that without the use of dynamite a greater portion of the drift at Johnstown would still be there untouched, and I have every reason to believe that much still remains under water and covered over with the sand and gravel which we shook loose from the drift, and naturally fell to the bottom. Before closing I must say I was very

much surprised at the evident ignorance of what appeared to be engineers of great experience in connection with dynamite. The simple pronouncing of the word dynamite in their presence appeared to make them shiver with apprehensive fear. That is a very disagreeable and foolish state of mind to be in. Every person, especially engineers, should know and always remember that all matter in the world is under certain fixed laws, and all we have to do is to understand those laws and obey them, and there is no danger with anything. For instance, no man understanding the laws governing oil and water would ever think of taking oil to extinguish a fire, nor would he ever take water to kindle a fire, but *vice versa*. So with dynamite. If you will only reflect for a moment that a very strong law of dynamite is that nothing but the sharp concussion of a peculiarily prepared cap or its equivalent of black powder or a ball from a strong gun can ever explode dynamite as now manufactured; I say if you bear this in mind it will free you from all fear or dread when dynamite is near your presence.

Discussion of the Paper of Mr. Kirk "On the Use of Dynamite at the Johnstown Jam.

W. L Scaife: I should like to ask Mr. Kirk what proportion of nitro-glycerine his dynamite contained? And I should also like to know if it is not dangerous to handle frozen dynamite?

A. Kirk: As to the percentage, we use a variety of percentages. It is customary to estimate the strength of dynamite by the percentage of glycerine in the compound. As, for instance, 20, 40 or 60 per cent. means that there are that many pounds of nitro-glycerine to the hundred, the remainder of the hundred being made up of sawdust and other absorbing ingredients. But what I used was made from a secret recipe, and the same rule does not apply in all cases. I should judge that all we used was equivalent to, commercially, 75 per cent.

As to the thawing of dynamite, of course our work was at a time of the year that did not require thawing, but I will mention here, for I suppose that is what the gentleman wishes, that all dynamite freezes at 42°, and in that condition is unexplodable

by any known means. The Prussians have gone very extensively into experiments about that, and have yet failed to discover any means of exploding frozen dynamite. But, if you will take notice, all the accidents that occur with dynamite are with the frozen article while in the act of thawing. In some very few instances, wilful carelessness is responsible. It is a common thing to expose frozen dynamite to a fire, and that is one of the most dangerous things you can do, or to lay it on a steam boiler to thaw it. That is a very dangerous act, for if it reaches a certain temperature, which is something approaching the temperature of steam at 60 pounds pressure, it will explode, and it will destroy the boiler.

The way I have found as most satisfactory for thawing dynamite is to have kettles prepared like glue kettles; the inside a removable chamber, water tight, in which you place the dynamite; that is surrounded by a body of water, say from 3 to 4 inches thick, and that in a vessel set on short iron legs, keeping it off the ground. You then expose the vessel to the fire, and you can charge that full for an ordinary quarry, and that will keep the dynamite thawed in the coldest weather, and you can use it the same as in summer.

W. L. SCAIFE: I have understood that there was some danger in using frozen dynamite, and so I asked the question. I may mention a case that came to my knowledge. A miner was using No. 1 dynamite which had become frozen, and, like most miners, he did not want to take the trouble to thaw it. He put a cartridge into a hole drilled in the mine, and it struck before reaching the bottom. He then drove it very hard against the rock. It exploded, and he was badly injured.

A. KIRK: Well, I may say about such cases that it is very difficult to get at the truth. For the last ten years I have made a special effort to find out the cause of every accident that I could hear of. We generally opened a correspondence, if we could do no better, with the postmaster at the nearest place to where the accident had happened, and we generally got the best information to be obtained. But there is a constant tendency among workmen to lie about cases of that kind. They will not tell the whole truth. Now, I will give an instance of that. We supplied dyna-

mite to open a drift up at Ben's Run, and a man was suddenly injured by a stick of our dynamite. That was published extensively, and in order to find out about it we made a special trip to get the facts. It turned out that the man was on the night shift, and he was about through. The rule was to do the drilling during the shift, and fire the charge immediately before the other shift came on, so that while one set of hands was retiring, the other could go on while the smoke had an opportunity to get away. Well, this man had drilled his hole and had got ready to fire, and here he found his dynamite was frozen. He grabbed up a half-pound cartridge, ran up to the entrance, blew up the blacksmith fire, and laid the cartridge on the fire. After blowing a little while he got tired and turned around, observing in doing so that there was a light as if it was burning. He picked up the cartridge, turned around to the anvil, and struck it against it. The cartridge exploded, tearing his hand and cheek, injuring him considerably. He was laid up for two or three months. I saw him afterwards, and he told me that his cheek inflamed and troubled him a great deal, and they had to poultice it. One day when they took the poultice off here were the fragments of a copper cap. How came they there? The only solution was that the shift before him had that dynamite ready to put in the hole, and the cap and fuse had become detached, leaving the cap on the cartridge. They had thrown it up on the bank opposite them, put in another cartridge and left the old one there. It was the cap which he struck against the anvil causing the explosion, and the fragments had been thrown into his cheek. So far as I am concerned, I feel perfectly safe in handling it all the time when it is frozen, or in thawing it. If you obey the laws connected with it there is no danger.

W. M. Phillips: I would be very glad to tell you all about this disaster, but of course you have all read about it in the newspapers, and after what Mr. Kirk has said I do not think there is much left. I was in Philadelphia when the disaster occurred. I received a message from Mr. Pitcairn, also others from General Hastings and Governor Beaver, requesting me to go to Johnstown to assist them. I had never had any experience of that kind

before, and do not think anybody else had. I met Colonel Douglass there and Colonel Sears of the regular army. Colonel Sears had been sent by the Government with pontoons. When we first went there General Hastings asked me if I would go down to the work. There had been so many suggestions made he hardly knew what to do. I went down, but between the dead bodies, the débris, and the disinfectants, it was almost impossible to stay there. I was very much disgusted, and wanted to go home when I saw it. I did not know where to begin. We divided the town into districts. I made a map of it and we sub-let the divisions out to the contractors. For instance, we divided the town into five districts. Cambria City and Morrellville was one district; the bridge and wreck another, and Kernville, Johnstown proper, and Conemaugh, which included Woodville, were the remainder.

Well, we began, as Mr. Kirk said, with all kinds of appliances. I had fifteen engines, most of them stationary, placed along the bank, using ropes and snatch blocks to pull away the débris. We put three engines on the bridge, pulling this way (illustrating). We found that we could not move the material. The wire in the river, I suppose, was the main cause. It was estimated at 150,000 to 200,000 pounds, and in coming down the river it had entangled itself amongst the trees and roots in every conceivable way. In that drift there was telegraph poles, street cars, dead bodies of horses, and everything you could think off. When I went there there was great opposition to the use of dynamite. I saw the absolute necessity of getting a channel through there, and went to General Hastings. He asked me if I thought we could cut through by Sunday, as on the score of health the matter was becoming very serious. I telegraphed to Pittsburg for 20,000 gallons of oil, and we tried burning, but that was useless. Then Colonel Douglass and myself held a consultation, and we told Mr. Kirk to go ahead; that we would take the responsibility. We began with small cartridges, and the result was very unsatisfactory. It would have done it in the end; no question about that, but the thing was not can it be done, but how soon could it be done. So on the last day I saw Mr. Kirk, and we resolved to go ahead with larger charges. The first charge was at 10 o'clock,

and was 400 pounds. It knocked down some chimneys, and the Cambria Iron people claimed they did not want the remains of the town destroyed, and threatened me with arrest. So I got Colonel Perchment to let me have a number of soldiers, to arrest any man found inside of the grounds when we were at work. This was done to avoid any one being hurt, as the place was full of relic hunters. About 2 o'clock we let go another one. They were going to arrest me, but I did not return for dinner. I went in the mines and took dinner with our men. At half-past two we let go another. Mr. Fulton, I believe, left his office, and about everybody cleared away. At half-past three we let go the last one we had, and the river was opened. We had a channel of an average width of 30 feet, with the water running perfectly free. It was opened three days from the time we began the work.

A curious thing about these charges we fired was the action of the dynamite; it did not seem to separate the drift or clear it, but it would cause the débris to fall right back again. It would clear a space as big as these two rooms, but, looking after the charge had been fired, we would not think it had done any good, but the moment the ropes were put to it it was a very simple thing to start it, and sometimes they started so quickly they would take a whole gang of men with them.

Well, there was the next difficulty—the worst difficulty of all. The drift, after being started, would clog at the bridge. I could not dynamite there except in very small quantities. But after we got that clear dynamite came into the very best use in the removal of the small drift-wood that we might build a bridge for the Cambria Iron Company to cross the Conemaugh opposite their great shops. It was necessary that they should get across to their metal and brick-yard, and we put up a temporary Howe truss bridge. We were greatly troubled with the logs lying there. We could not have gotten rid of them promptly with 50 cross-cut saws. I got some of Mr. Kirk's dynamite, and, I think, inside of two and a half hours, I cut nearly every log into small pieces, across the top or wherever I wanted them cut. We abandoned the saws, and in that way I cleaned the river nearly down to Sang Hollow.

When it came to clearing up the river above, we used dynamite

nearly altogether. When we got up opposite headquarters General Hastings asked me to make a channel there to prevent the water flooding the tents. We could not cut the wire, however, but, as it became detached, it sank to the bottom, and so we could make a channel there. We could not cut that wire while in coil. We pulled out all we could.

One great mistake, gentlemen, I will say here, as I said in the report I made to the State, the thing was a bungled job from the beginning. I mean by bungle that while the work of clearing was going on, and during the whole summer and fall, no attempt was made to locate a permanent channel for the Conemaugh river, the result being the river, after ordinary rains, floods a large area of ground, and it would have been much easier to dredge a permanent course before building was commenced than at present. The material taken out should have been used for raising banks on the sides of the stream. The material was principally gravel and pebbles, with a considerable amount of stone mixed with it. And in the shape the river has been left you will see next spring, when the snows melt, that they will experience great difficulties again. There is no river there. I will just give you an instance. They are building a bridge up there called number 6, above the Conemaugh. The contractor was to finish that bridge by the first day of November or forfeit $100 per day. He was getting along first-rate. He thought it was an easy job from the appearance. He dug down 12 feet. He came to where he found kitchen utensils, tin cans and everything of that sort, and he is still digging and has no foundation yet. That is the Conemaugh river to-day. The river is entirely changed. I told Captain Hamilton, who succeeded me, that it was all useless to make any special arrangements that were to be permanent. You can see all the way up to the dam, on the hillsides, the stones have been rolled over and over and the whole topography has been changed. The people do not seem to be aware of the change, and any attempts you make to change the course of the stream as it ought to be, brings out complaints of encroaching on somebody's property.

Of course, the immediate cause of the disaster has been removed. That cannot occur again; but in my judgment, and I do not think

I am wrong, I examined the dam carefully, and I do not think it could hold enough water to cause all the damage unless there was a great water-break back somewhere else. By water-break I mean, at some point distant back of the South Fork dam a large quantity of water must have come down in a solid body from a cloud-burst or some other cause, and this mass of water, together with the large volume already stored, was the cause of the terrible destruction.

A. E. HUNT: With the present river it would seem to be perfectly feasible to put in retaining walls, and let the stream, in a great measure, scour its own bed, only removing the large boulders. Is not there area enough to carry the stream as it is now?

W. M. PHILLIPS: You can hardly say the "stream." The whole course of the stream is still there, the position is still there, but the water does not run in the same path.

A. DEMPSTER: Has the bottom above the bridge been washed away?

W. M. PHILLIPS: Oh, yes, sir. To give you an instance: I saw Mr. Brown the other day, and he read me the riot act; said I was trying to blow down their bridge. And yet the depth of water was 22 feet. About 100 feet up stream from the bridge, where the water was about 6 feet above ordinary summer depth, this hole had the appearance of being scored out by logs, trees, buildings, etc., at the time of the jam.

T. P. ROBERTS: What was the original depth of the creek above the bridge?

W. M. PHILLIPS: About 6 or 8 feet. This mass of stuff came down and struck the bridge square and then came up. Everything was floating there. This formed an eddy. Where the street railroad went through, the river was nearly on the same level. It was all filled up, and the material was carried some 300 feet down and deposited there. Now, then, dynamite did not do that. I believe the Pennsylvania Railroad expected something of this kind when they built that bridge. It is not built perpendicular to the course of the stream. They put dowels on each course of stone on the face of piers below the water. They had placed sheet iron

or steel plates, and riveted it to the pier so as to protect the stone. Well, I found one of these plates away up stream. It could not have been blown up there. (?) But there is one thing you can see, that dynamite has done no damage apparently. The force of the explosion may have shown some signs of its shock in the cemented joints, but I failed to find any serious damage done. While I was in charge there were no shots of dynamite fired near the piers. Very small charges were fired near the abutments in *the drift*, and most of these were on the level of the water, or a few feet below. What was done after I left (early part of July), I cannot say. Mr. Hamilton, the engineer who took charge after I left, used dynamite about the bridge, but it was not in large charges, and I am told it was not close to the piers. I understood that Mr. Brown, of the Pennsylvania Railroad, issued positive orders to the effect that, for a specified distance which he named, no dynamite should be used. This was in the middle or latter part of July. The bridge is very badly burned by fire, and then, in some places, the face of the stone is cracked and blistered, but that does not hurt the bridge.

In that connection, if you will remember, the old bridge and the new bridge are not built on the same foundation. The force of the water took even the lowest course of the foundation stone of the old bridge, and yet some of these stones were found above or up stream.

A. DEMPSTER: If you had 40 feet of depth of water you would certainly have a scouring force equal to that head to force a channel through the archways of the bridge, and it does not occur to me that there should have been any difficulty in clearing out that channel to the depth it was before.

W. M. PHILLIPS: No, I think you are in error in regard to the facts. If there had been any means of carrying off the water that had fallen during the rain, a great number of persons would not have been drowned; but as it was, the water was 4 or 5 feet deep in the town before the dam broke, which prevented people getting away. Hundreds of people could have been saved if they could have gotten away from their houses to high ground.

A. DEMPSTER: I am one of those of whom Mr. Kirk was

speaking as not being present to see the Johnstown disaster, but I do not profess to know more than those who were there, but I believe that I can account for that steel facing going up stream. The head of the water, being obstructed in its course by the bridge, formed a current in the opposite direction, and the force of it may have carried the steel casing away from its location to the point where it was found. Some years ago I had some experience in this direction on the Allegheny river at Oil City. The river was "bank full," and the current very strong. Six of us tried to stem the tide in a skiff. While passing round the head of a barge the five got scared and jumped on the barge with precipitation, and, in doing so, capsized the skiff, which was quickly swept under the head of the barge, and by coolness and agility the other saved himself. Whilst the skiff passed under, the others rushed to the lower end of the barge to see the skiff come to the surface and catch it, but they looked in vain, and, having given up the watch, they started to the shore, and in doing so they had to cross another barge which lay between the one under which the skiff was swept and the shore, and which lay nearly the length of itself above the outer one, and, on walking along, one of the party discovered the bottom of a skiff in the débris collected at the head of the outer barge which they thought would serve in lieu of their own that was lost, but, to their astonishment, when they took it out and turned it up, they discovered it was their own that they had looked for to emerge at the lower end of the barge.

A. Kirk: Perhaps I can throw a little light on the break on that pier. We had been blasting, and had gotten up about 100 feet from it, doing very nicely, but still there was a lot of stuff sticking just below the water, and no matter how we worked that would catch our other drift and stop it, and we concluded to put a blast down and remove it. This stuff turned out to be a lot of frame houses. We got rid of that, when we discovered what turned out to be a tree about 5 feet in diameter with a stump of tremendous size. It would have made a splendid mast. I had to blast it to pieces. This log was lying as if this was the pier (illustrating), and here was the stream running past the pier that lost its cut-water. That log was lying in just about that position to it.

The log had evidently come down and struck that pier and likely swung around against the shore and was lying there at the bottom of the stream where we did not think there was anything left. But the blasting of these old frame houses off the top of it caused it to jump up out of the water, and it had no doubt come down with the flood and gave that cut-water a slanting blow and loosened it. The cut-water must have been held in position by this sheet of steel you speak of. I never heard of it before. Well, that remained that way all the time we were blasting, and about the last week there was a lot of stuff banked up against this pier, something of a slanting position (illustrating). This log was catching everything that was coming down, and if we left it that way we saw it would soon form another jam on the bridge, so I concluded to put in a charge about 5 feet from the pier. I lowered it down on that slanting car-bed some 5 or 6 feet from the pier and fired it just before dinner. When we came back we found the channel open, but the cut-water on that pier had tumbled off, and no doubt it fell up stream. It could not be otherwise; and that might account for that sheet of iron being up there. But as to injuring the pier with the dynamite, that is out of the question, and I just happened to find evidence of that accidentally. I was standing talking about it, and inquring around, and finally I found the foreman of the masons. Mr. Houston, I think, was his name. I asked him about it. Said he: "Mr. Kirk, do not give yourself any uneasiness about that; I know that there was a crack 5 or 6 feet from the point of that cut-water, so that I could put my hand in it, before you fired a shot at the bridge." When I fired that shot which cut away that slanting sunken car-bed the pier cut-water tumbled up stream. I was taken to task very severely about it by the head lawyer and chief engineer of the Pennsylvania Railroad. I was surprised by their coming down to interview me; they were going to ride right over me, and hold me for doing that damage to the pier. I said my knowledge of dynamite enabled me to say the pier was never injured by dynamite; it could not be; the way the blasts were put off they could not have injured the pier. But they would not listen to that, and said they were going to hold me resposible for the damages. All right, said I,

you can just hold, but your head mason told me that before I fired a shot near that bridge there was a crack in the pier from the top of the cut-water as low as I could see, and I could put my hand in it. "All right, Mr. Kirk," they replied, "if he said so, you are free."

T. P. ROBERTS: I know dynamite to-night is the subject, but there has been a little wandering occasionally. One remark made by Mr. Dempster, in regard to the condition of the bed of the stream in regard to building dykes. I think that is the only solution for the preservation and safety of that town. During this winter they will be subject to floods, as they are having now, I believe. As Major Phillips has stated, the Conemaugh has wandered from its course, particularly so towards the upper end of the town. Its present bed is also higher than the old one, and greatly impeded with drift gravel, boulders, and débris of all kinds. What is needed is a new permanent course of ample section, to be secured in part by dredging, and in part by water-tight embankments. It is unfortunate that the owners of lots are likely to interpose objections to a wise system of improvements, but as the work will positively benefit more property than will be lost by condemnation, assessments ought to balance legitimate claims. It is possible, also, that certain streets might have to be changed; but no matter, the property will still be there, and more valuable than it is at present. Johnstown should appoint a commission with ample power, and should do this at once, for the longer the work is deferred the more it will cost in the end.

A. E. HUNT: I should like to ask a question on the general subject of dynamite, and that is to know if Mr. Kirk or any one else can give an intelligent reason why the action of dynamite seems to be almost invariably downward? Why is it so different from the action of, say, gunpowder? I had occasion once myself to use these explosives in blowing up an ice-gorge that was injuring a bridge. In a portion of the stream the ice had collected and made a solid wall to the bottom of the stream; in this location dynamite cartridges did the most good, breaking the ice up in large areas with every shot. But where the ice was thinner, gunpowder worked better, as the dynamite only broke the ice in limited areas around

each shot, while the slower working gunpowder shattered the ice much more. That is only an illustration. The question is, why is the action of dynamite, if there is any reason, more vertically downward in its action different from gunpowder?

A. KIRK: I may answer that by relating an anecdote that happened a good many years ago. Major Swope was United States attorney here. Dr. George Hayes, the chemist, was called as an expert to determine whether some damage had been done by black powder or dynamite. Mr. Swope put the question to him: "Mr. Hayes, will you please explain to the judge and jury the difference between the explosion of black powder and dynamite?" "Black powder, sir, does not explode." "Oh, I thought powder exploded." Mr. Hayes: "Some ignorant people think so, but it only burns."

That may be the solution of the whole thing. Dynamite is a chemical compound of bodies that have more or less affinity for each other. Black powder is a mechanical compound of ingredients that have no affinity for each other. It is merely put together mechanically. It only burns and that is one reason why people think that dynamite blows down more than black powder. I cannot, for the life of me, understand how an explosive substance can have more power downward than upward.

A. E. HUNT: It does.

A. KIRK: The reason I think is rather this: that black powder is of a different nature altogether from dynamite. The Prussian Government has spent immense sums to utilize dynamite as an instrument of war, but they have abandoned it now for the reason that its explosion is so instantaneous in all its parts that it does not give the ball time to start before it has shattered the gun that held it. Black powder begins to burn pretty quick, but it has a beginning, as is evident from the fact that when you want to test a gun as to what it will burn, it is a common thing with sportsmen to shoot over white sheets or over new fallen snow until they find unburnt powder, showing that it only burns. There was that much left unburnt when the pressure escaped at the muzzle of the gun. Now, my idea is, that the instantaneous explosion of dynamite produces more of a commotion than is made by black powder,

the idea being that the force will seek the weakest place to escape. The action of a dynamite blast is to make 8 cracks radiating from the centre as true as the spokes of a wheel. It will be said that you can see more of the result from a dynamite explosion than in the case of powder, but I do not think that the pressure can be any more one way than another, because when we want to make a successful blast in a side-cut, or along the side of a hill, we make the holes in a row, 10 feet from each other; that makes it that each hole has to exert a pressure only 5 feet when fired by electricity, until it meets the pressure from the other hole. That makes the bottom of the holes the weakest part, and finding vent in that direction the pressure is naturally downward. The blow of dynamite, I may say, is like the blow of a tilt hammer—it just strikes what it comes in contact with, and it does that so quick that the atmospheric pressure is sufficient to produce the action below.

W. M. Phillips: I can give you another idea of that. We fired some small charges in front of the commissary department at Johnstown. Some one placed a good-sized stone on top of the dynamite (about 6 or 8 pounds), and this was fired a long distance, and lit on the roof of a building at the Pennsylvania railroad station, doing some damage. The stone must have gone 1800 or 2000 feet. This was below the Public School. During all the work while I was there I knew of but one accident, and that was to a man on the bridge, who was struck by a flying stone. He was not seriously hurt.

A. E. Hunt: Mr. Kirk has answered the question. I thought the same way, but I wanted to get his idea. In other words, all explosions of that nature are occasioned by the sudden expansion of what was a solid into a gas of very much larger volume. Now, with nitro-glycerine the formation of the expansive gas is almost instantaneous, quicker at least than with powder, and from ten to thirteen times larger volume of gas is produced; therefore, the action will be much more rapid than with powder, the powder taking a much longer time to be converted into gas of only $\frac{1}{13}$ the volume of the nitro-glycerine gas. The quickly expanded gas finds its line of least resistance upwards, and therefore does not exert as much force in a downward direction. The difference is

that the one agent resolves itself into an explosive force more rapidly than the other, and develops a much larger volume of expanded gas.

T. P. ROBERTS related a laughable incident of his first experience with dynamite when trying to raise a rock on Herr's Island. He dug a hole under the rock, put in his cartridge, and filled up the hole with gravel. The natural effect was of a cannon, and boulders and gravel flew in all directions. It created so much excitement that he thought it best not to relate it before.

J. A. BRASHEAR related and illustrated on the blackboard the result of some experiments made by Prof. Munroe of the Newport Torpedo Station, where a number of cartridges were exploded on steel plates that had been hardened. Suppose we have here a cartridge and there is a conical depression in it. When this cartridge was exploded upon the plate, one would naturally expect that if there was a depression in the cartridge that there would be an elevation left in the steel plate after the explosion, but in every case the reverse took place, and there was a depression that corresponded to a depression in the bottom of the cartridge. Probably twenty steel plates were used, and the result in each case was the same. I do not attempt to explain this curious phenomenon. At the meeting of the American Association of Sciences, where the paper was read and the result of experiments shown, some tried to explain it on the principle of the "resolusion" of forces.

He also spoke of an explosion in his work-shop of fulminate of silver, by which almost everything breakable was destroyed, but strange to say the windows were not shattered in the least.

A. KIRK: I would repeat, that dynamite only affects the parts that it comes in immediate contact with. It is local in its blow. It is working a complete revolution in marine work, and can be used where black powder cannot. You can put it down in the water without anything around it at all except the manilla paper, and fire it with perfect success. In fact, I had intended to embody in my paper that one day I lost two 50-pound cartridges. I was getting them ready to fire in a place where the current was very swift, and just as we got ready to touch them off here came

a lot of drift wood, cut away the wires, and took the boxes down stream. I offered a reward of two dollars a box. We afterwards recovered both of them and I fired them. It had lost but one-half its original strength after being in the water a week. I also tried some that had been washed from the stores in Johnstown that had been through the flood, and had been in the water for some considerable time, and I believe it was just as strong as when first made.

A. E. HUNT: On the subject of danger in handling dynamite, I have an illustration. I had a friend who was connected with the Chester works something like five years ago. The question came up in my professional work of testing the relative amount of nitro-glycerine in a lot of different makes of dynamite. My friend, the chemist of the explosive manufacturing works, had also made some analyses, and I had written him saying the method he had used was rather a dangerous one in the way he separated the nitro-glycerine. He wrote back saying that there was no danger; that he had just as lief handle it as butter or oil. While that letter was in the mails, before I had a chance to read it, I read in the papers the account of the blowing up of his factory and his death, so that even if a man knows how to handle it, nitro-glycerine is a dangerous thing, and I trust my friend Kirk has not created an impression in the minds of any one present that it can be handled, even in the shape of dynamite, as you would "butter or oil."

F. C. PHILLIPS: The curious fact Captain Hunt has mentioned, that dynamite seems to exert its force principally downward, may have another explanation. Some time ago Mr. Frank Dupont, of the Wilmington powder works, told me that experiments they had made at their works led them to believe that nitro-glycerine, at the moment of explosion, may cause complete vaporization of surrounding solid bodies, so that explosion of nitro-glycerine actually tends to induce an explosive change in such apparently stable and harmless substances as common salt and sulphate of magnesia.

These substances undergo so complete a dissociation or disruption that they may be said to explode. When a dynamite cartridge is placed on top of wood or rock, as in blasting, it is possible

that these hard resistant bodies undergo a more or less complete volatilization near the point of contact. The air above the cartridge is too elastic to propagate the shock in its original severity. The shock seems to be greatest downward because that is the direction in which it meets with the more or less inelastic resistance of solid bodies.

W. L. SCAIFE: Outside of the chemical influence Mr. Phillips has just mentioned, it seems to me that the explanation of the physical effects may be put a little more simply. The expansion of dynamite is so rapid that, when it rests on a solid substance, the air forms a sort of wall or buffer, which causes the gases to react downward. If there was no atmosphere, or if the explosion occurred in a vacuum, the gases would expand to fill the vacuum, and would produce no effect on the supports except that due to their own weight. I have seen holes in hard rock filled with cartridges of dynamite, but covered with nothing except the air. Their explosion would produce a certain amount of broken rock. When the holes were tamped with water, the effect was still greater. Similar holes filled with dynamite, and strongly tamped with clay, were much more effective than the preceding. In short, the downward action of dynamite depends on the pressure or confinement to which it is subjected.

EMIL SWENSSON: I once had an experience with dynamite, in which case it acted solely in an upward direction. I was then in charge of the opening up of a new feldspar mine on the west coast of Sweden. Powder was first tried, but without satisfactory result; indeed, hardly with any visible effect on account of the crystalline structure of the mineral, the products of the powder explosion filling the interstices simply. Dynamite was next used and well tamped in, and the result of its explosion was something very beautiful. Around each hole a funnel or rather an amphitheatre had formed, the feldspar having split in right-angled benches, beginning a few inches above the bottom of the drilled hole.

Society adjourned about 10 o'clock.

S. M. WICKERSHAM,
Secretary.

DECEMBER 17TH, 1889

SOCIETY met at 8 o'clock P.M. President Brashear in the chair. Vice-President Scaife; Directors, Becker and Metcalf and 28 members and visitors.

C. I. McDonald and J. R. Reed were duly elected to membership.

The following paper was read on

STONE USED FOR STRUCTURAL PURPOSES IN ALLEGHENY COUNTY, PA.

BY ALFRED E. HUNT.

THE writer is very glad to record the fact that the large buildings of Pittsburg are very properly being built almost entirely of granite, sandstone, or brick, as these three materials form the most lasting masonry, in almost every climate, but are especially adapted for a large manufacturing city like Pittsburg. Except for the public spirit and decisive action of members of our chamber of commerce, some of whom are members of our Engineers' Society of Western Pennsylvania as well, we should have had probably a limestone building instead of the granite structure that is progressing slowly—but we all trust, surely—towards completion for the Government Post Office and United States Courts.

Limestone or even marble, which is a metamorphic variety that is susceptible of taking a good polish, will very soon deteriorate in an acid atmosphere, such as is ours. Our City Hall is built of a white sandstone; although it is a monument of the old smoky days of Pittsburg before the advent of natural gas, and one would not know from its looks that it had ever been white, it was quarried some twenty miles up the line of the Allegheny Valley railroad; a stone that quarries easily and is susceptible of being dressed smooth, as is evidenced by the front of the City Hall. This stone hardens considerably on standing, and is an excellent building stone.

Trinity Church, on Sixth Avenue, and the German Evangelical

Church on Smithfield Street are built of Massillon, Ohio, sandstone. It has not weathered very well, and does not bear evidence of being a very durable stone.

The Masonic building and the Duquesne Club are of red Connecticut river sandstone from Massachusetts.

The Marine National Bank and the Grant Street Lutheran Church, the East Liberty Presbyterian Church and Moorehead residence, Ridge Avenue, Allegheny, are built of varying colors of Beaver Valley sandstone, one of the best; and on account of its abundance and of its proximity to Pittsburg, also one of the cheapest building materials for ordinary masonry work for our district. This stone is close-grained and somewhat uneven, and does not admit of a very smooth finish in dressing, and is not susceptible of being polished at all. At the same time, in the above-mentioned large fronts, it compares very favorably for beauty with granite; and to the taste of the writer, it is infinitely superior—its rugged face speaking of honest endurance and strength—to the smooth surface of marble or the fine finish of limestone, with its lack of durability.

The writer is not aware of a single large building in our district built of limestone or marble—a fact that is quite remarkable for a district of its size.

The Allegheny County Court House is built of granite from Stoney Creek, Mass., and its inside stone work is mostly of Beaver County sandstone. The Fidelity Title and Trust Company building, the new Post Office building, the German National Bank, the Pittsburg National Bank of Commerce, the Keystone National Bank and the Hussey building are built of granite, most of them of the white granite of Hallowell, Maine.

The Westinghouse building on Penn Avenue and Ninth Street is built of brick and terra cotta, and granite from Belfast, Maine, and the Schmidt building of brick and red Scotch and Quincy granite.

Marble from around Rutland, Vermont, is used very largely for inside decorations, as well as the celebrated white marbles from Italy, and of late years, a rather coarse-grained gray marble from Georgia has been extensively used.

The well known pink and variegated marbles of Eastern Tennessee are much used in interior decorations as well, and would have much larger uses were it not that they are so unsound, much loss being occasioned thereby in sawing and otherwise working them.

The Ligonier quartzite, found in the Ligonier Valley, and, in a pink variety, on the line of the Baltimore and Ohio railroad, is an excellent hard and durable stone, and is an illustration of the fact that unfortunately our most durable stones are so extremely hard and difficult to work, having no natural cleavage planes, as to make them expensive and almost impossible to use in dressed masonry work. This stone, like the trap rock and older crystalline or metamorphic primitive quartz, makes excellent road metal, street pavements or ballast, but is so hard and difficult to dress as to not only make it very expensive for building materials, but also, where dressed stone are necessary, not durable as well, for they are so hard as to crack often in being dressed, these fine splits or cracks absorbing moisture and afterwards splitting out the stone by the action of the frost.

The table of qualities (page 152) is found to be about the average of the building stone used in our district.

The modulus of rupture in transverse strength was found by the following formula:

$$R = \frac{W}{\frac{2\,bd}{3\,l}}$$

The co-efficient of transverse strength was found by the following formula:

$$C = \frac{W}{\frac{bd}{L}}$$

The relative value of the crushing strength to the size of the cubes tested corresponded quite approximately to Gen. Gilmore's formula of $Y = A\sqrt[3]{X}$.

A = Crushing pressure of an inch cube of the same material.
Y = Total crushing pressure in pounds per square inch.
X = Length in inches of edge of cube under trial.

b = Breadth in inches.

d = Depth in inches.

l = Length in inches.

R = Modulus of rupture in pounds per square inch.

C = The weight in pounds to break a bar an inch square and one foot long between bearings.

Kind of stone.	Weight per cubic foot in lbs.	Relative loss under exposure action of soda-sulphate test, hard burn'd brick being taken as one.	Weight of water absorption of dry stone in per cent. of weight of stone.	Specific gravity.	Coefficient of elasticity.	Coefficient of transverse strength.	Modulus of rupture.	Crushing strength of two-inch sawed cubes in lbs.	Ultimate crushing strength per square inch, in lbs.	Ultimate crushing strength in tons per square foot.
Vinal Haven, Me., granite..	165	1	$0.66\frac{2}{3}$	2.62	5,500,000	100	2000	80,000	20,000	1440
Concord, N. H., granite.....	175	1	0.33	2.64	8,000,000	110	2200	76,000	19,000	1368
Gloucester, Mass., granite ..	168	1	0.33	2.58	6,500,000	115	1800	72,500	18,100	$1303\frac{2}{10}$
Quincy, Mass., granite.....	170	1	0.20	2.62	8,500,000	110	2100	82,000	20,500	1476
Beaver Valley sandstone, green with quarry sap.....	150	5	2.00	2.38	.....	75	1300	48,400	12,100	$871\frac{4}{10}$
Same dry after being weathered	140 to 145	5	4.00	2.40	5,000,000	70	1200	56,000	14,000	1008
Connecticut River brown sandstone.....	140	11	2.00	2.60	.....	75	1400	42,000	10,500	756
New Jersey brown sandstone.....	145	12	3.33	2.50	.....	70	1200	32,000	8,000	576
Lockport, N. Y., gray limestone.....	150	10	1.00	2.70	5,000,000	90	1300	48,800	12,200	878
St. Albans, Vt., white marble.....	170	2	0.33	2.68	2,500,000	120	2000	74,000	18,500	1332
Italian white marble.....	165	2	0.33	2.65	2,700,000	125	2200	76,000	19,000	1368
Georgia gray marble.....	158	3	0.80	2.60	2,300,000	100	1700	66,000	16,500	1188
East Tennessee pink marble	165	5	1.00	2.65	2,900,000	120	1900	70,000	17,500	1260
East Tennessee variegated marble.....	160	9	1.00	2.70	2,000,000	80	1100	42,000	10,500	756
Hard pressed brick	150	1	2.00	2.15	4,500,000	50	1100	34,000	8,500	612
Common building brick average	120	12	$12\frac{5}{10}$	2.10	3,000,000	40	900	32,000	8,000	576
Granite from Petersburg, Va.....	165	1	0.50	2.62	.....	.....	.....	100,400	25,100	$1807\frac{2}{10}$

W = Concentrated load applied in centre plus one-half of the weight of the beam itself in pounds.

L = Length of the beam in feet.

Baker, in his work on *Masonry Construction*, gives the following estimates of safe pressure loads for different kinds of masonry:

Concrete, 5 to 15 tons per square foot.

Rubble, 10 to 15 tons per square foot.

Squared stone, 15 to 20 tons per square foot.

Good brick laid in lime mortar, 15 to 20 tons per square foot.

Good brick laid in cement mortar, 20 to 30 tons per square foot.

Limestone ashlar, 20 to 25 tons per square foot.

Granite ashlar, 30 tons per square foot.

In actual practice in our district the loads are nearly all of them less than the least figures quoted, the maximum load allowed on any of the sandstone bridge piers in the district being not over 250 pounds per square inch, or 18 tons per square foot in any case.

The Beaver Valley sandstone most used for bridge piers is capable of sustaining a load of from 25 to 30 tons per square foot, if precautions are taken that the loads shall be uniformly distributed, and if the loads are not applied until the mortar in the masonry has had time to become thoroughly dried. It is this precaution especially, both in masonry and brick work of buildings that more care should be taken with in our district. The disaster at the Willey building was a terrible illustration of the necessity of allowing mortar to become thoroughly dried out before placing on it great superincumbent weight and surface having to withstand wind pressure. In wet weather it often takes many weeks before the mortar has become even reasonably dry and coherent enough to give any bond whatever.

Where high walls are to be erected with great speed, a good portion of quick drying cement should be mixed with lime mortar, and great care should be taken with the mortar and the method of laying the brick, recognizing the fact that the mortar joints are by far the weakest points in masonry. The bricks should be pressed into the mortar so as to force the mortar into the interstices near the surface of the brick to strengthen the adhesion.

	Lbs. per cubic ft.
Hard pressed brick, with their joints, weighs,	145
Soft brick, with their joints, weighs,	100 to 125
Concrete masonry weighs,	130 to 160
Dressed granite, with mortar joints, weighs,	150 to 165
Dressed limestone, with mortar joints, weighs,	150 to 165
Dressed sandstone, with mortar joints, weighs,	135 to 145
Ordinary mortar weighs about,	100

Stone for structural purposes may be classified into natural and artificial stone.

Natural stone may be classified according to their physical structure and according to their chemical composition.

According to their physical structure, rocks are either stratified or unstratified. The stratified rocks are of the more recent geological formations, and were deposited as sediment or drift from water, in layers of plain divisions of often unequal thickness, some of them being only $\frac{1}{8}$ of an inch in thickness, others of many feet of thickness.

Pittsburg being situated in the centre of the vast coal measures of the Palæozoic basin, the great majority of the stone found in the vicinity are of a sedimentary or stratified character. Some of the more compact of these stones make strong and durable building stones, as the sandstones of the Beaver Valley. But, as a rule, the stratified stones are not as durable or as strong as the older unstratified rock, one reason for which is, that these older rock of igneous or metamorphic origin, found near enough to the surface to be quarried, have stood the test of ages, and are the survival of the fittest, being by their very existence an evidence of their durability; the softer, more easily decomposed rocks, formed contemporaneously with them, having been eroded and worn away, becoming in many cases "the stock" from which the newer stratified rocks have been formed. In other words, Allegheny county is rather handicapped by its geological position in the matter of prevalence of many kinds of good, durable and strong building stone.

The stratified rock have the following varieties:

I. Fine crystalline, example marble. There are many of these stones which are both durable and strong; none, however, are found nearer to Pittsburg than Tennessee or Vermont.

II. Coarse granular crystalline, in which the grains adhere firmly together, as in gneiss, or are cemented together, as in sandstone, by some cementing material. Some of these stones are compact and durable; most of them, however, are porous, friable and weak. There are many varieties of this sort of stone in our neighborhood.

III. Compact granular structure, in which the grains are very fine, and firmly adhere one to the other. Most of these stones are strong and more or less durable. Our best sandstones and limestones are of this class.

IV. Porous granular structure, in which the sub-divisions of the stone are coarse and loosely bound together. The vast beds of clay shales in the coal measures are illustrations of this kind of stone. They all have a very low degree of strength and durability. Many of these stones have Palæozoic shells bound into their structure.

V. Slaty structure, easily split into layers, which are not necessarily along the lines of stratification, but according to certain cleavage-planes, occasioned by pressure and strains produced in the stone by geological action. Most of these stones are very weak and easily broken up, and, like the stone of the class mentioned above, often make very untrustworthy foundations upon which to build masonry. There are vast deposits of this class of stone in our vicinity.

VI. Conglomerates, where the material is non-homogeneous, nodules of one kind of stone being imbedded in a matrix of another. The writer does not know of any of the stone of this class that are good building materials found in this district, although some of the conglomerates found in the eastern portion of the State make good structural stone, and the celebrated Roxbury pudding stone of Eastern Massachusetts is highly prized as a durable building stone.

The unstratified building stone are mostly of compact crystalline structure; granite, trap, and basalt are good illustrations of such rock.

According to their chemical composition, building stones are mostly of three classes—siliceous, argillaceous or calcareous.

The siliceous stones have over 50 per cent. of their constituent parts silica. Such stone are mostly crystalline or fine granular, and are the most durable rock we have. The principal building stone of this class are granite, syenite, gneiss, basalt, greenstone, trap, quartz, sandstone, mica or hornblende slate.

The argillaceous building stones have clay or a silicate of alumina as a prominent constituent; porphyry and clay slate are among

the most prominent stones of this class. There are not very many durable stones among them. In fact, an argillaceous stone is almost a synonym for a very unenduring one. One of the defects with almost all stones of this class is that they absorb moisture freely, and are consequently injured by freezing and thawing.

Calcareous stones are those in which lime predominates mostly as a carbonate or silicate. Many of these exist as very pure carbonates of lime, as marble and many grades of limestone. Others are combined with magnesia carbonates, and in this case are called dolomites. These dolomites are, as a rule, much more durable than the ordinary limestones. Others of these have considerable sand, clay or oxide of iron mixed with them.

In some cases, where the stone is not subjected to the action of acids, and where the calcareous particles are firmly bound together in a compact mass, these stones are very durable; but in the moist and acid atmosphere of a large manufacturing centre like Pittsburg, subject as it is to the extremes of heat and cold, by which the minute interstices of the stone are alternately attacked by corrosion and by the disintegrating power of freezing water, limestones are comparatively short lived and not durable. The same remark also applies to sandstones in which the cementing material has much lime in it, or has much hydrated sesquioxide or protoxide of iron, clay, or organic matter contained in it, for such substances are more or less rapidly eaten out and cause the disintegration of the entire rock.

The agents which attack the lifetime and strength of a stone in our vicinity are:

Variations in temperature, by which the particles of stone are alternately expanded by heat and contracted by cold, causing a moving of the particles of the stone one upon another, and a loosening of the binding or cementing qualities of the material, or, more seriously still, by the freezing of the absorbed water and consequent expansion of the ice, acting like a wedge to throw the rock faces apart.

Rain, which in Allegheny County becomes considerably charged with carbonic and sulphuric acid, acts as a solvent of the cementing portion of many building stones. Stratified stone should

always be laid with its layers of stratification, or, as is said in many masonry specifications, with its natural beds horizontal, for in this way the solvent action of the rain is less upon the stone. Laid the other way, each line of stratification becomes a furrow or channel, down which the water will run, and corrode and disintegrate the material.

For bridge piers and abutments, retaining walls and pavements, the wear of constant friction is a serious cause of destruction, and for such work special care should be taken that the rock selected should be tested as to its power to withstand attrition in the various ways in which it is likely to be subjected. Some sandstone, for instance, which will serve excellently well to withstand the friction of water in a rapidly moving stream, would still wear out very rapidly for pavements; hardness and weight both are required in such work.

In some of our older buildings, vegetation should be noted as one of the causes of deterioration of rock, especially as it is built up in masonry; the intruding creepers of vines, lichens and mosses seeking out the interstices in the rock, and enlarging them and then decaying, giving to the water that percolates into these small places added chemical strength as a solvent to the cementing portions of the stone; and in most kinds of stone it is this cementing portion of the rock that gives to it strength and durability as a whole, but unfortunately in most rocks it is also this cementing portion of the material which is the easiest taken into solution by water charged with various acid, or organic alkaline chemicals.

The best qualities to be looked for in a building stone are, to be not easily acted upon by chemical action; hardness, compactness and solidity combined with ability of being cheaply quarried and dressed, and non-absorption of moisture.

One of the best ways to test these qualities is to note the action of the weather upon the rock in exposed portions at the quarry, taking into consideration the way the rock lies, and the probable treatment to which it has been subjected, and the varying atmospheric changes to which it will be subjected in its proposed new site in our acid, moist and alternately warm and cold atmosphere,

from the pure and perhaps naturally even and dry country atmosphere in which it has perhaps stood finely, with sharp edges and old surfaces, having apparently stood for ages without being deeply corroded. This point is well illustrated in the famous Cleopatra's needle, which has stood for ages, a finely hewn and engraved block of syenite in the dry and even atmosphere of Egypt, and which is now rapidly deteriorating in the moist and acid atmosphere of New York City.

Some forms of rock harden considerably by exposure to the atmosphere; the cementing material of the outside faces of the rock forming very hard hydrated masses, which aid a great deal in the preservation of the rock.

Some forms of rock need to be weathered to allow them to dry out. Such rock will often lose from 5 to 10 per cent. in weight from drying out of "sap water." Our Beaver Valley sandstones are very good illustrations of the above. They are much softer and more friable, and are much more easily worked while the quarry sap—a solution of silicate of soda, together with some silica held in solution by organic matter—is still in them. After allowing them to weather for a year they become much harder, and seem to harden gradually for years after being quarried, by the gradual precipitation of the silica in the water of hydration contained in the rock. Some stone dries out much more rapidly than others, due to its peculiar structure. The writer has noticed this phenomenon even with bridge piers where the rock has been under water, that the Beaver Valley sandstone gradually hardened after being quarried, if allowed to weather for a time at the quarry before being laid in the work.

The writer believes, in the case of these sandstones, that the difference is in the losing of a part of the water of hydration, that is the chemically combined water in the silicates of the binding material of the rocks, making this binding material much harder and consequently making the rock much stronger.

Microscopical examination of thin cuttings of the rock will tell very considerably as to the quality of the binding cement as well as the character of the minerals, often a good many in number, comprising a building stone. With a knowledge of the character

of the minerals and the way they are bound together, considerable has already been done, and much more can be done to aid our knowledge of the durability of various building stones.

Absorption tests of the relative amount of moisture absorbed by a given quantity, say a cubic inch of building stones, is of considerable use. A stone having a large absorption power will generally form a very unenduring stone in a climate like ours, subject to the expansive heavings of frost and ice. Another test of similar character is to saturate a weighed portion of the stone to be tested in a concentrated solution of sulphate of soda, and afterwards dry in a warm atmosphere; the sulphate of soda crystallizing in the pores of the rock will have an expanding action somewhat similar to that of frost. The salt solution is then washed out by repeated soaking in warm water, the specimen dried and the loss by weight noted. In this way the relative loss of various kinds of stone will give an approximate idea of the relative durability under the action of frost. These tests, however, show with sandstones what has been confirmed by experience, although it would at first seem somewhat anomalous that the coarse-grained sandstones, especially of the Beaver Valley, stand better the action of frosts than the finer, closer-grained sandstones, like the brownstone of the Connecticut Valley, although the coarser-grained stone absorbed considerably more moisture. This is due to the stronger, closer combination of the cementing material. The color and a close examination of the surface of a sandstone will tell considerable as to its durable qualities. Feldspar, distinguished by its fine grain and compact structure, is especially bad, as it more rapidly decomposes. Clay also is bad, and a blue-colored limestone, colored with clay, which is a prevalent country rock in our district, and much used for cellar foundations of dwelling houses, should be avoided for exposed masonry work as weak in its power to withstand the ravages of time. The best and most durable sandstones are light in color, close in texture, and free from streaks of clay or other impurities (called by the quarrymen "dries"). Limestones not only absorb more moisture, but lose more weight by the expansive action of frosts, or of the soda sulphate solution, than do sandstones. Hard granites

and compact crystalline marbles absorb the least moisture of all, although in the case of marbles, owing to its brittleness, there are almost always fine cracks in it which absorb moisture, and in such cases they are very weak to the action of frost.

The crushing strength of stone is most often referred to as the relative "strength" of a stone for building purposes. This is by no means the crucial test of the strength of a stone, when by the word "strength" we mean to add, as it often does, to those who do not look into the matter carefully, the durability of the stone. As pointed out before, its solubility, hardness, compactness, and closely knit cementing qualities, its failure to absorb moisture, and its uniformity, should all be taken into consideration with its crushing strength per square inch in thus speaking of its strength. The crushing strength of stone is usually determined in cubes of 2 inch base. It is important in comparing the relative crushing strength of a series of stones that the size in which they were crushed be reasonably the same. This is not absolutely necessary, for if the stone be reasonably homogeneous the results should be comparatively the same, although inequalities in the bearing faces would much increase errors by comparing cubes of various sizes. It is best to use every precaution that the pressure be uniformly applied to the bearing face; to this end it is the writer's practice to place many layers of thick blotting paper directly above and below the cubes to be tested, and to also test both under and over a smooth surface of soft pine wood, and to note that the indentation in this wood is uniform and equal in depth. All stone should be tested relatively the same way as to its location in the bed-rock, as stones are always much stronger with their bed-faces laid down. Specimens should always have their bed-faces properly marked upon them with a pencil.

Sawed specimens always give better results than those chiselled out by hand, and the facts of the way the specimens are prepared should be noted on the report of the tests, and should be taken into consideration in comparing various results as to crushing tests of stone. These results often vary as much as 25 per cent. or more, whether hand-dressed or sawed to shape. The way the rock breaks should always be noted under remarks upon crushing tests, as the

facts give some idea of the character of the stone; hard homogeneous crystalline, or metamorphic, rock cubes snapping off sharp, often with considerable violence, the break starting in the centre of two opposite vertical faces of the cube as it is being tested, the lines of the cracks running off in sort of pyramids or cones to points near the corners of the faces taking and bearing the pressure; the portions of the faces outside of these lines with a thickness sometimes from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch being thrown off for some distance. Softer, more granular rock do not act in this way, but seem to cripple and bulge out in the centre, while non-homogeneous material gives way at the points of demarcation of the weaker materials.

Stone, as it is cut out from the quarry in irregular shapes, is called rubble. Most cellar foundations of dwelling houses are built of this kind of stone, cut from the country sandstone into pieces whose weight is not too great to be handled by one mason in laying. That portion of the rock cut off in irregular shapes in squaring the blocks is called "spalls." These "spalls" are used in heavy mason work to fill the interstices between the irregular course rock, and is called "backing." It is relative to the leeway allowed in the use of this backing with rough mortar that most of the poor mason work is found. These spalls are also used for lining the bottom and side walls of streams, to prevent the water cutting or scoring the earth from under the mason work. Such use of it is called "rip-rap." Most of all the bridge piers in the rivers of our district are protected by "rip-rap."

Building stone are usually roughly squared at the quarry to give good joints, and are face hammered on both top and bottom beds. This is popularly called by quarrymen "dressing the stone to beds and joints." When the stone are allowed to go into the work in this condition, as they often are in rough masonry, as in bridge piers, abutments and the like, it is called in the specifications generally "quarry-faced stones." Nearly all of our bridge piers and retaining walls are built of quarry-faced stone.

When for a space of an inch or so from the edge the stone is dressed approximately true to given dimensions and the rough projections are cut off with a pitching tool to a given distance

from the edges, they are called "pitched-face stone." Most of the sandstone used in our buildings are pitched-face stone.

"Drafted stones" are those in which the surface around the edges are made very smooth, and edges are made exact to dimensions with a chisel-draft. This is a favorite finish for the granite blocks in many of our public buildings.

The dressing of the surface of the stone in our buildings is either "rough pointed" or "fine pointed," according to the amount of projection allowed to remain; the dressing being accomplished with a pointed tool of round or octagon steel, with blows of the hand hammer or mallet; "pean hammered," if chiselled to a finish with a pean hammer; "bush hammered," if smoothed with a flat hammer; having many points on its face, called a bush hammer. There are very few of these latter mentioned varieties of finish on our Pittsburg masonry, as the stones used are so coarse as not to admit of them.

With marble, sandstone, and some of the softer stones, the faces of the blocks are sometimes sawed to a smooth face and the blocks afterwards rubbed smooth.

Ordinary brick are made by pressing mixtures of clay, with more or less sand, into rectangular blocks of regular sizes, and, after drying out, heating in kilns until the structure becomes semi-vitrified. Such brick made from our own native clays, together with tiles and terra-cotta work for ornamentation, are about the only variety of artificial stones used in the Pittsburg district, with the exception of masses of concrete used in the foundations of some of the iron and steel mills. This concrete is not as often used as it could be advantageously in mill foundations. The writer believes that large concrete blocks built *in situ* with protected binding bolts to hold the blocks firmly together and with suitable wells to get at the broad base washers and bolt heads form the best kind of mill foundations. They are nearly as cheap in first cost as brick work, can be readily cut apart, and, if built conveniently with grooves in the middle of the blocks, they can easily be handled in taking down the foundations.

Ordinary brick, chemically, are silicates of alumina, with some

silicates of lime and magnesia, and oxide of iron; the latter constituent giving to the brick their well-known red color.

Clay fire-brick are made in a general way similarly to red building brick. They are made of purer clays containing less oxide of iron or alkalies, the sum total of which should not be over 3 or 4 per cent. in good fire-brick.

Silica fire-brick are made of ganister rock, bound together with milk of lime and well pressed and calcined at a very high heat. The amount of lime should not be over 3 or 4 per cent. of the weight of the silex.

The requisites for good brick for building purposes are that they should be fine, compact, and of uniform texture and color. They should be hard and give a clear ringing sound when struck a sharp blow. They should have a specific gravity of at least 2.00. When whole brick are air-dried for three days in a warm room and then weighed and afterwards immersed in water in the open air for forty-eight hours and dried in the air until the surface becomes dry, say three hours, and again weighed, the increase in weight ought not to be over 10 per cent. from absorption of water. The brick should have plane surfaces, parallel sides, and sharp straight edges and reasonably accurate right angles.

The crushing strength of full-sized brick when ground flat and pressed between thick metal plates, distributing the load uniformly, should be at least 280,000 pounds, or 8500 pounds per square inch. The modulus of rupture of the brick should be at least 1000 pounds per square inch. The size of the brick should be close to $8\frac{1}{4}$ inches by 4 inches by $2\frac{1}{4}$ inches, and the weight should be $4\frac{1}{2}$ pounds each, or 120 pounds per cubic foot of brick.

The use of pressed brick in various fancy shapes, and even of carved work in brick and terra-cotta, has come much into vogue of late, and very neat and attractive designs have been executed within the past few years, both in residences and some of the large building blocks of the city.

The increase of ornamentation and pretense of ornamental architectural designs in large office buildings, stores, and other business blocks in our city, in stone and iron buildings, is a very favorable indication of the prosperity and growth of our city.

There are many very handsome building fronts of iron in Pittsburg, as well there should be in "the Iron city."

The writer has hopes later of seeing aluminum castings as well used in the ornamentation of our large building fronts, as this metal casts readily into any desired shape, is as strong as cast-iron and will hold its lustre without tarnishing.

Discussion of the Paper of Alfred E. Hunt on Building Stones of Allegheny County.

Max Becker: It does seem rather strange that this particular part of the country, which is so very rich in minerals of almost every kind, should be so destitute of good building material. I have often had occasion to notice and to regret this; because, whenever we want to do any work requiring masonry, we have to ransack this whole country in order to find suitable material. But perhaps this scarcity of a much-needed article of daily necessity has some redeeming feature in this, that in a city where some specially good building material abounds, its use becomes universal, and the architecture generally assumes a dead uniformity and a monotonous appearance; whereas, here in Pittsburg, where we must draw our building supplies from the country at large, the variety which is being introduced into our architecture is producing a pleasing effect, although it is no doubt accomplished at the expense of the enterprising gentlemen who are doing the building.

Some kinds of native building stone, which have been made to answer, have not turned out very well in the end. As an illustration, I might refer to the old (now defunct) courthouse, which, I think, was built of an argillaceous sandstone which abounds in this neighborhood, and which, in the course of time, decomposed and became so badly abrased by the weather, that notwithstanding all efforts to preserve its appearance by painting and other measures, was disintegrating at a rapid rate, when the fire caused its final destruction.

The Beaver sandstone, which is found on our border, while it is a very good building material for ordinary purposes, such as bridge work, does not commend itself for architectural purposes,

because you cannot produce a very nice effect by it. A few houses on Penn Street have their fronts built of this stone, but they do not strike me as very attractive.

There is one kind of stone in this country which is not alluded to in Captain Hunt's paper, and which has never received the attention it really deserves, on account of its very superior quality, but which is gradually coming into notice, and that is the oolitic limestone of central Indiana. It is a very compact and perfectly durable, almost indestructible, building material, not only for rough purposes, but it also admits of a very high polish. It is used extensively now in the neighborhood, where it appears for ornamental purposes, tombstones, monuments, etc. The new soldiers' monument in Indianapolis is being built of it. We have been using it very freely for bridge work, and it has no superior, to my knowledge, anywhere, unless you go into the very expensive kinds of granites and marbles.

The oolitic limestone of Indiana belongs to the sub-carboniferous group, and to that particular formation known in the Geological Reports of the Western States as the "Saint Louis Limestone" or "Cave Limestone."

It occurs in a massive ledge, varying from 30 to 70 feet in thickness, free from the stratified partings which characterize other limestone, and may be quarried in blocks of any size or form required, limited only by the capacity of the appliances for handling and transportation.

It possesses great strength and elasticity, works freely, both by hand and machinery, carves to clean, sharp lines, and is susceptible of a high polish. It is a nearly pure carbonate of lime (95 to 98 per cent.), free from perishable ingredients, and consequently indestructible by ordinary atmospheric influences.

Owing to these properties it is rapidly gaining favor in the leading markets, and the demand for it is steadily increasing.

This formation extends from the Ohio River in Harrison county, Indiana, northwesterly to the Illinois State line, but does not attain important development north of Owen county.

It is worked at points on the I. & V. R.R. between Gosport and Spencer, and also at Stinesville, Ellettsville, and Bloomington,

in Monroe County, Bedford and vicinity in Lawrence county, and Salem in Washington county.

The belt of surface in which the stone outcrops is about 8 miles wide in Owen county, 10 miles in Monroe, and widens out to about 16 miles in Lawrence county.

In the latter county the valleys of all the larger creeks have been cut through the limestone formation, leaving the rock exposed on the hillsides, and presenting many points for successful quarry work. This is particularly true of the valleys of Salt Creek and of Leatherwood Creek.

When sawed, its modulus of rupture is 2338; compression, 12,675; elasticity, 4,889,480. When tool dressed, its modulus of rupture is 1477; compression, 7857; elasticity, 2,679,475. These figures are taken from a series of experiments made by Mr. Th. H. Johnson, member of this Society, and published in the Annual Report of the State Geologist of Indiana for the year 1881.

This stone was mentioned at one time as a possible material to be used for the completion of that edifice which Uncle Sam has been building during the last fifteen years here in Pittsburg.

A MEMBER: What is the cost?

M. J. BECKER: It can be delivered in the rough, of suitable sizes to be used for bridge work, for instance, for about 15 or 16 cents per cubic foot. It can be delivered, sawed on the top and bottom, for about 20 cents; and sawed on all sides for about 20 or 28 cents; these prices are for the stone delivered at Indianapolis.

MR. HOAG: That is for the better quality. They have two or three qualities besides.

M. J. BECKER: I refer to what is called the Bedford limestone.

I. M. HOAG: At the Bedford quarries they have two or three colors; two shades in one stone. Their inferior stone they sell at 8 or 10 cents, and then the better quality at 25 to 28 cents.

M. J. BECKER: I do not think the color has anything to do with the quality; it merely affects the appearance. Of course the outcroppings may not be so good in color, but when you get into the interior this defect disappears.

MR. SCHNEIDER: There is one point not yet mentioned in this

discussion. It seems to have been overlooked, and that is the power of the various building materials to resist extreme heat. All cities are subject to great conflagrations, and it seems to me it is very important to understand how any building material will act under such exposure.

M. J. BECKER: I would like to ask Mr. Schneider if he ever built an ash-pit on a railroad of any kind of stone that stood.

MR. SCHNEIDER: I have built a great many that did not last; but this is the point: If a building will resist extreme heat for an hour, or two hours, it may be saved. We do not expect a building to resist heat forever, but a few hours might save it.

W. L. SCAIFE: I might say in answer to Mr. Schneider's question that I visited Boston after the great fire with the idea of seeing how the so-called fire-proof buildings had stood the test there. I wandered all over the burnt district, and found that granite was not good to resist heat at all. Nearly all the granite buildings had been affected by the intense heat, and had crumbled to a kind of mortar, especially where water had been thrown on them. Brick stood very well, in most cases not seeming to have been affected at all. One fact, however, was impressed on my mind, that granite as a fire-proof material is very undesirable.

A MEMBER: I think that was also shown in a good many instances in the Chicago fire. Granite fronts would burst when exposed to heat, when the fire was on the other side of the street.

J. A. BRASHEAR: In connection with this, although not directly bearing upon the matter of building stones, I would like to ask what is the general method of cutting up and quarrying stone? I ask the question from the fact of having had a chat lately with some gentlemen of our city who are producing what they call a "crushed steel," to be used in connection with stone cutting. They tell me that it is becoming largely used in the eastern quarries, and it expedites the work very much. They report that it expedites the work at least 33 per cent. I examined quite an amount of the crushed steel under a microscope. They have what they call a "crushed steel" and a "crushed steel emery." What they call "crushed steel" I examined under the microscope. Most of the grains were sharply angular, and were either of a blue tint or

straw color; but few grains in the whole mass were of the gray-white color of "glass" hand steel itself. But when I examined the "crushed emery steel," I could not see any colored grains, except an isolated one here and there. We have not yet tried any of it in the processes of cutting glass, but propose to do so at an early date. The manufacturers claim that they depend upon the sharp angular corners of the grains to do the cutting, and claim it will last much longer than emery, for ordinarily as long as there are any grains not broken down or worn out they keep on cutting. Emery seems to break down and quit cutting in a short time; so does corundum. I should think it would be interesting to see this tried on building materials. In the matter of the size of these grains I saw particles as fine as No. 150 emery, and from that they ran up to nearly $\frac{1}{8}$ inch, and the particles or grains were quite uniform. In the abrading material known as the Tilghman-shot, which is made of chilled iron, I found nearly twenty different sizes, all sold as one number, but in this crushed steel there were not more than two or three sizes.

Wm. Metcalf: I am very largely interested in that crushed steel. We are trying to make some dies for these people that will crush the confounded stuff. As I understand the process, they put high carbon steel, such as old files and material of that kind, to a very great heat,—what we would call over-heating for any ordinary purpose,—then they quench this steel in water so as to cause it to become excessively hard and brittle; then the pieces are put in a little stamp-mill and stamped. Afterwards the pieces so broken are, I suppose, sifted, and I think the uniformity of which you speak is probably due to passing through uniform sieves, making the variety of sizes uniform.

I am informed that this steel is not only cheaper than emery, but vastly quicker and does handsomer work, that it makes a finer polish, and puts it on quicker and better in every way than emery. As to these larger pieces, if the steel was not pounded very much, it would show such a variety of color as you mention, because the steel would crack in the water, and the surfaces would oxidize to the different colors.

J. A. Brashear: We generally use No. 50 shot for the abrad-

ing of surfaces, and it does it in a very few minutes, but emery is soon transformed into slush; this shot cuts as long as it stays on the wheel. It has the drawback,—not a very expensive one,—that when the coarse material is used on an iron wheel it can never be used for any fine work afterwards. The coarser particles seem to embed themselves into the iron wheel, and you must use one wheel for coarse work and another for fine work.

There being no further discussion the Society adjourned.

S. M. WICKERSHAM,
Secretary.

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LIST OF MEMBERS.

Date of Membership.		
May 21, '80.	Aiken, Henry,	Homestead, Pa.
Jan. 6, '80.	Ackenheil, Chas.,	Chief Eng. B. & O. R. R., Elizabeth, N. J.
Mar. 20, '88.	Aikman, Edw. G.,	150 Broadway (Room 95), New York.
Oct. 20, '85.	Albree, C. B.,	18 Market St., Pittsburg, Pa.
Apr. 20, '80.	Amsler, Chas., M.E.,	Bissel Block, Pittsburg, Pa.
Dec. 16, '84.	Anderson, J. W.,	45 Fremont St., Allegheny, Pa.
Jan. 6, '80.	Armstrong, Edw.,	Supt. Alleg. Water Works, 160 Webster Ave., Allegheny, Pa.
Jan. 6, '80.	Armstrong, H. W.,	Metcalf, Paul & Co., Pittsburg, Pa.
Jan. 18, '87.	Arms, W. F., M. E.,	R. & P. C. & I. Co., Punxsutawney, Pa.
Nov. 20, '88.	Arras, John W.,	P. O. Box 485, Pittsburg, Pa.
Apr. 15, '90.	Ashworth, Daniel,	Hamilton Building, Pittsburg, Pa.
Feb. 21, '82.	Aull, W. F., C. E.,	Manager Denny Estate, Box 91, Pittsburg, Pa.
Jan. 6, '80.	Awl, John L.,	Mgr. Monong. Incline Plane, Pittsburg, Pa.
Sept. 20, '87.	Bailey, Chas.,	Wilkinsburg, Pa.
Sept. 16, '84.	Bailey, Jas. M.,	Mfr. Sligo Iron Works, Pittsburg, Pa.
Jan. 15, '84.	Baker, Chas. H.,	Metcalf, Paul & Co., Verona, Pa.

Date of Membership.		
May 18, '84.	Bakewell, Thos. W.,	Bakewell Building, Pittsburg, Pa.
June 19, '88.	Bakewell, Wm.,	110 Diamond St., Pittsburg, Pa.
Apr. 17, '88.	Barbour, Geo. H.,	20 Portland Block, Chicago, Ill.
Feb. 17, '80.	Barret, Jonathan,	Hamilton Building, Pittsburg, Pa.
May 19, '85.	Barnes, Phineas,	Jones & Laughlins, Ltd., Pittsburg, Pa.
Nov. 21, '82.	Bates, Onward,	C. Eng., C. M. & St. P. R. R. Milwaukee, Wis.
Jan. 6, '80.	Becker, Max. J.,	C. Eng., P., C. & St. L. Ry., Pittsburg, Pa.
Jan. 20, '85.	Beckfield, Chas.,	804 Duquesne Way, Pittsburg, Pa.
Nov. 19, '89.	Bell, W. G.,	P. O. Box 976, Pittsburg, Pa.
Jan. 19, '86.	Bennett, C. M.,	Supt. Eng. C., St. L. & P. R. R., Richmond, Ind.
Dec. 18, '83.	Benney, Jas.,	Emsworth, Pa.
Jan. 6, '80.	Bigelow, E. M.,	Chf. of Dept. of Public Wks., Pittsburg, Pa.
Feb. 19, '89.	Billen, C. E.,	Pencoyd Bridge Cons. Co., 261 S. 4th St., Phila., Pa.
Mar. 18, '91.	Black, S. W.,	99 4th Ave., Pittsburg, Pa.
Mar. 21, '82.	Blake, F. C.,	Penna. Lead Works, Mansfield Valley, Pa.
Sept. 18, '83.	Blank, Hugo,	Chemist, 77 4th Ave., Pittsburg, Pa.
Jan. 11, '89.	Blaxter, G. H.,	Allegheny Co. Light Co., Pittsburg, Pa.
Mar. 18, '84.	Bole, W. A.,	Supt. Westinghouse Mach. Co. 25th and Liberty Sts., Pittsburg, Pa.

Date of Membership.		
Jan. 6, '80.	Borntraeger, H. W.,	Keystone Bridge Co., Pittsburg, Pa.
Apr. 15, '90.	Bothfield, Charles,	Bridge and Iron Works, Detroit, Mich.
Apr. 19, '81.	Boyd, Henry A.,	National Tube Works, McKeesport, Pa.
Mar. 18, '84.	Brashear, John A.,	Optician, Observatory Ave., Allegheny, Pa.
Nov. 16, '80.	Bray, Thos. I.,	Warren, O.
Apr. 19, '87.	Breen, H.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 6, '80.	Brendlinger, P. F.,	C. E. Schuylkill Valley R. R. R. Co., Pottsville, Va.
Jan. 19, '86.	Brockett, Alonzo H.,	Mellor & Hoene, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Browne, Geo. H.,	Supt. Water Works, Pittsburg, Pa.
Jan. 6, '80.	Brown, W. R.,	City Engineer's Office, Pittsburg, Pa.
Apr. 18, '82.	Brunot, H. J.,	Greensburg, Pa.
Jan. 16, '83.	Buchanan, C. P., Jr.,	P., C. & St. L. R. R., Pittsburg, Pa.
Feb. 9, '86.	Buel, A. W.,	Care of Chf. Eng. Mich. Cen. R. R.
Jan. 18, '87.	Buente, C. F.,	Stone Contractor, Duquesne Way & 10th St., Pittsburg, Pa.
Jan. 6, '80.	Bullock, W. S.,	Taylor & Bullock, Pittsburg, Pa.
Sept. 21, '80.	Burgher, Rutherford,	W. P. R. R., Springdale, Pa.
Jan. 6, '80.	Butz, E. M.,	Architect, 132 1st Ave., Pittsburg, Pa.
Jan. 19, '86.	Cadman, A. W.,	Brass Manufacturer, Pittsburg, Pa.
Feb. 9, '86.	Campbell, Harry C.,	Nat. Gas Burners, 6 Ninth St., Pittsburg, Pa.

Date of Membership.		
Dec. 20, '87.	Campbell, Hugh C.,	Duquesne Forge, Rankin Station, Pa.
May 23, '82.	Camp, Jas. M.,	Tarentum, Pa.
Feb. 20, '83.	Carhart, Danl.,	C. E., Prof. Math. and Eng., Western University, Allegheny, Pa.
May 19, '85.	Carlin, Thos. H.,	Machinist, 186 Lacock St., Allegheny, Pa.
Nov. 18, '84.	Carlin, David,	Mgr. W. G. Price & Co. Iron and Lead Works, 5th Ave. and Price St., Pittsburg, Pa.
Apr. 20, '80.	Carnegie, Andrew,	Steel, 55 Broadway, New York.
Mar. 18, '91.	Caughey, E. G.,	15 North Ave., Allegheny, Pa.
Sept. 18, '83.	Chambers, J. S., Jr.,	C. E., Box 212, Trenton, N. J.
Feb. 17, '80.	Chess, H. B.,	Chess, Cook & Co., Nails and Tacks, Pittsburg, Pa.
Nov. 21, '82.	Clapp, Geo. H.,	Chemist, 95 and 97 Fifth Ave., Pittsburg, Pa.
May 19, '89.	Clark, Louis J.,	Western Pa. Phonograph Co., 146 Fifth Ave., Pittsburg, Pa.
Jan. 18, '88.	Clark, R. N.,	Rustless Iron Co., 32d and Smallman Streets, Pittsburg, Pa.
Oct. 16, '83.	Coffin, Wm.,	Draughtsman, Franklin St., Allegheny, Pa.
Apr. 19, '87.	Colby, J. A.,	Penn Building, Pittsburg, Pa.
Sept. 18, '89.	Colon, Thos. F.,	Western and Grant Aves., Allegheny, Pa.
Feb. 22, '81.	Cooper, Chas. A.,	Bakewell Building, Pittsburg, Pa.
Dec. 20, '81.	Cooper, John W.,	Draughtsman, Pitts. Locomotive Works, Allegheny, Pa.

Date of Membership.		
Nov. 19, '89.	Cornelius, W. A.,	Hazlewood, B. & O. R. R., Pittsburg, Pa.
Apr. 15, '84.	Cueto, Jose de,	Union Bridge Co., Athens, Pa.
Sept. 21, '80.	Curry, H. M.,	Lucy Furnace Co., Pittsburg, Pa.
June 19, '88.	Cunningham, A. C.,	G. W. G. Ferris & Co., Hamilton Building, Pittsburg, Pa.
May 23, '83.	Danse, L. O.,	Architect, Helena, Montana.
June 19, '88.	Davis, Chas. H.,	1026 Pine Street, Philadelphia, Pa.
Jan. 6, '80.	Davis, Chas.,	County Eng., Court House, Pittsburg, Pa.
Dec. 21, '80.	Davidson, Geo. S.,	McCance Building, Pittsburg, Pa.
Jan. 6, '80.	Dempster, Alex.,	C. E., Coal Operator, Stevenson Building, Pittsburg, Pa.
Mar. 18, '84.	Dickson, Thos. H.,	P. O. Box 672, Pittsburg, Pa.
Jan. 6, '80.	Diescher, Samuel,	M. E., Hamilton Building, Pittsburg, Pa.
Apr. 19, '81.	Dixon, C. G.,	Contractor, 34 Park Way, Allegheny, Pa.
Nov. 15, '87.	Dobson, Thos. H.,	Engineer, W. P. R. R., Shadyside P. R. R., Pa.
Apr. 15, '84.	Dravo, H. G.,	Iron Mcht., 413 Wood St., Pittsburg, Pa.
Jan. 18, '88.	DuBarry, H. B.,	Office Ch. Eng. Pa. Lines, Pittsburg, Pa.
Jan. 22, '89.	DuPuy, H. P.,	Westinghouse Building, Pittsburg, Pa.
Jan. 18, '81.	Eckert, E. W.,	C. E., Room 224 Aldrich Ct. Bldg., No. 45 Broadway, New York.

Date of Membership.		
Jan. 6, '80.	Edeburn, W. A.,	Eng. and Surveyor, Bakewell Building, Pittsburg, Pa.
Mar. 18, '91.	Edwards, J. P.,	Uniontown, Pa.
Jan. 6, '80.	Ehlers, Chas.,	City Eng., No. 8 City Hall, Allegheny, Pa.
Feb. 27, '88.	Engle, Geo. W.,	Eng. Gen. Office Penna. Co., Pittsburg, Pa.
Sept. 19, '82.	Engstrom, F.,	Engineer, Penna. Co., Pittsburg, Pa.
Feb. 4, '88.	Estrade, E. D.,	Engineer, Chief Eng. Office, P., C. & St. L. Ry., Pittsburg, Pa.
Nov. 15, '87.	Euwer, A. H.,	Lumber Merchant, Allegheny, Pa.
Dec. 20, '87.	Felkel, Frank,	335 Main St., Lawrenceville, Pittsburg, Pa.
Mar. 6, '86.	Ferris, Geo. W. G.,	C. E., Insp. of Iron and Steel, P. O. Box 539, Pittsburg, Pa.
Apr. 19, '87.	Fielding, J. S., C. E.,	Care of Jas. Inglis, 17 Oxford St., Rochester, N. Y.
June 16, '85.	Fisher, S. B.,	Engineer, Green Bay, Wis.
Jan. 20, '85.	Fitler, F. K.,	121 Water St., Pittsburg, Pa.
Apr. 16, '89.	Fleming, H. S.,	Cameron Iron and Coal Co., Emporium, Pa.
Jan. 18, '87.	Follansbee, Gilbert,	Supt. Chamber of Commerce, Pittsburg, Pa.
Sept. 22, '87.	Fortune, W. W.,	Engineer, Turtle Creek, Pa,
Feb. 21, '82.	Frank, Isaac W.,	Founder, Lewis Foundry Co.. Pittsburg, Pa.
Jan. 6, '80.	Frost, A. E.,	Prof. of Physics, W. U., Perryville Ave., Allegheny, Pa.
Apr. 17, '88.	Fulton, Louis B.,	Chancery Lane, Pittsburg, Pa.

Date of Membership.		
Jan. 19, '86.	Geisenheimer, W. A.,	608 Fifth Ave., Pittsburg, Pa.
Apr. 15, '90.	Giles, W. A.,	Schmidt Bldg., Pittsburg, Pa.
Oct. 16, '83.	Glafey, Frederick,	Keystone Bridge Works, Pittsburg, Pa.
Feb. 17, '80.	Goodyear, S. W.,	Waterbury, Conn.
Jan. 21, '90.	Goodwin, J. M.,	Sharpsville, Mercer Co., Pa.
Jan. 6, '80.	Gottleib, A.,	Room 75, Major's Block, Chicago, Ill.
June 16, '85.	Grant, Horace E.,	119 First Ave., Pittsburg, Pa.
Apr. 20, '86.	Gray, W. C.,	Gray's Iron Line, Pittsburg, Pa.
Apr. 21, '85.	Griffen, A. L.,	Keystone Bridge Co., Pittsburg, Pa.
May 19, '85.	Grimes, J. B., M.D.,	327 Carson St., Pittsburg, Pa.
Sept. 19, '82.	Gwinner, Fred., Jr.,	Contractor, Allegheny, Pa.
Mar. 20, '83.	Hackett, Geo. W.,	Cement, Lime and Terra Cotta, 1009 Library St., Pittsburg, Pa.
June 15, '86.	Halstead, J. C.,	C. E., Insp. of Iron and Steel, G. W. G. Ferris & Co., Hamilton Building, Pittsburg, Pa.
Oct. 15, '89.	Handy, J. O.,	95 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Harlow, Jas. H.,	Hydraulic Engineer, 411 Wood St., Pittsburg, Pa.
Apr. 19, '81.	Harlow, Geo. R.,	Hydraulic Engineer, 441 Wood St., Pittsburg, Pa.
Dec. 16, '84.	Hay, Saml. W.,	512 Hamilton Building, Pittsburg, Pa.
Jan. 6, '80.	Hemphill, Jas.,	Machinist, Mackintosh, Hemphill & Co., Pittsburg, Pa.
Nov. 14, '85.	Heron, Fred.,	Supt. Phœnix Iron Works, Phœnixville, Pa.

Date of Membership.		
Jan. 19, '86.	Hetzel, Jas.,	Box 346, Canton, O.
Apr. 19, '87.	Hibbard, H. D.,	Hainsworth Steel Co., Pittsburg, Pa.
Nov. 20, '88.	Hoag, I. V. Jr.,	43 Sixth Ave., Pittsburg, Pa.
Apr. 20, '80.	Hoffstot, Frank N.,	Iron Broker, Water St., Pittsburg, Pa.
Sept. 18, '88.	Hohl, L. I.,	Ruth St., 32d Ward, Pittsburg, Pa.
Dec. 18, '88.	Holland, W. J.,	Fifth Ave., Oakland, Pittsburg, Pa.
Nov. 15, '87.	Hopke, T. M.,	Linden Steel Co., Pittsburg, Pa.
Oct. 16, '88.	Howe, H. M.,	241 Beacon St., Boston, Mass.
Oct. 18, '81.	Hunt, A. E.,	Chemist, Schmidt & Friday Bldg., Pittsburg, Pa.
Jan. 22, '89.	Hunt, H. E.,	Emerson St., E.E., Pittsburg, Pa.
Mar. 17, '85.	Hunter, Jas.,	323 Carson St., S.S., Pittsburg, Pa.
Oct. 18, '87.	Hyde, C.,	Eng., Room 23, Lewis Block, Pittsburg, Pa.
Mar. 18, '80.	Jarboe, W. S.,	14 Garfield Ave., Allegheny, Pa.
Dec. 18, '88.	Jenkins, J. B.,	98 Arch St., Allegheny, Pa.
Feb. 22, '81.	Jennings, B. F.,	Preble Ave., Allegheny, Pa.
Jan. 18, '88.	Johnson, Thos. H.,	Penna. Lines, Tenth and Penn Sts., Pittsburg, Pa.
Apr. 19, '81.	Jones, B. F.,	Iron Manufacturer, Pittsburg, Pa.
Mar. 20, '88.	Jones, W. Larimer,	Jones & Laughlins, Ltd., Pittsburg, Pa.
Nov. 16, '80.	Kaufman, Gustave,	814 Hamilton Building, Pittsburg, Pa.

Date of Membership.		
May 18, '80.	Kay, J. C.,	Machinery, Kay Bros. & Co. Water St., Pittsburg, Pa.
Feb 17, '85.	Kay, Jas. I.,	Patent Attorney, 96 Diamond St., Pittsburg, Pa.
June 19, '88.	Keating, A. J.,	Iron Mfr., Zug & Co., Pittsburg, Pa.
May 21, '89.	Keenan, J. J.,	Holidaysburg, Blair Co., Pa.
Mar. 17, '85.	Kelly, J. A.,	28th and Smallman Sts., Pittsburg, Pa.
Jan. 16, '85.	Kelly, J. W.,	Road Master P. & W. Ry. Youngstown, O.
May 18, '86.	Kennedy, Julien,	48 Fifth Ave., Pittsburg, Pa.
Sept. 19, '82.	Kenyon, L. H.,	Pitts. Locomotive Works, Allegheny, Pa.
June 19, '88.	Kenyon, Edw. H.,	G. W. G. Ferris & Co., Hamillton Building, Pittsburg, Pa.
Mar. 19, '89.	Kerr, A. C.,	Third Ave., Pittsburg, Pa.
Mar. 18, '91.	Kerr, C. V.,	42 Clifton Park, Allegheny, Pa.
May 15, '88.	Kettredge, G. W.,	Engineer, M. of Way, Pittsburg, Pa.
June 19, '88.	Kimball, Frank I.,	Mining Engineer, Greensburg, Pa.
Feb. 21, '82.	King, T. M.,	B. & O. R. R., Baltimore, Md.
Mar. 16, '82.	Kirk, Arthur,	Arthur Kirk & Son, Powder and High Explosives, 910 Duquesne Way, Pittsburg, Pa.
Nov. 15, '87.	Kirkland, A. P.,	Supt. W. P. R. R., Allegheny, Pa.
Apr. 19, '87.	Klages, Geo. W.,	Machinist, Foreman, 130 Eleventh St., S.S., Pittsburg, Pa.

Date of Membership.		
Apr. 19, '87.	Koch, Walter E.,	Supt. Spang's Steel Works, Sharpsburg, Pa.
Jan. 6, '80.	Laing, Geo.,	1004 Penn Ave., Pittsburg, Pa.
Nov. 20, '88.	Langley, J. W.,	136 First Ave., Pittsburg, Pa.
May 19, '85.	Lauder, Geo.,	48 Fifth Ave., Pittsburg, Pa.
June 19, '88.	Lean, D. R.,	Lean & Blair, Engineers and Contractors, Pittsburg, Pa.
Jan. 17, '88.	Leech, Louis D.,	44th St. and Centre Ave., Pittsburg, Pa.
Apr. 15, '84.	Leishman, John A.G.,	Lewis Block, Pittsburg, Pa.
May 16, '80.	Leschorn, Alex.,	M. E., Phœnix Bridge Co., Phœnixville, Pa.
Mar. 16, '80.	Lewis, J. L.,	Lewis Foundry and Machine Co., Ltd., Pittsburg, Pa.
Apr. 20, '80.	Lewis, W. J.,	Linden Steel Co., Pittsburg, Pa.
Feb. 21, '82.	Lindenthal, Gustave,	Engineer, Lewis Block, Pittsburg, Pa.
Oct. 16, '88.	Linkenheimer, A. E.,	141 Federal St., Allegheny.
Sept. 16, '84.	Lloyd, Henry,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
May 19, '81.	Lloyd, John W.,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
Oct. 19, '80.	Loomis, Geo. P.,	Iron Mfr., Crescent Steel Works, Pittsburg, Pa.
Jan. 6, '80.	Lowry, Jos. L.,	Hydraulic Eng., City Hall, Pittsburg, Pa.
Jan. 6, '80.	Macbeth, Geo. A.,	Keystone Flint Glass Co., Pittsburg, Pa.
Apr. 19, '81.	Malone, M. L.,	Engineer, 320 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Martin, Wm.,	Resident Eng., Davis Island Dam, P. O. Box 70, Pittsburg, Pa.

Date of Membership.		
Dec. 18, '83.	Mead, Edwd.,	P. O. Box 124, Louisville, Ky.
Jan. 6, '80.	Melber, Fred.,	P. O. Box 155, Sharpsburg, Pa.
June 18, '89.	Mellor, Walter E.,	77 Fifth Ave., Pittsburg, Pa.
Mar. 20, '88.	Meredith, John R.,	60 Seventh St., Pittsburg, Pa.
Mar. 20, '88.	Mesta, Geo.,	C. E., Vice Pres. Leechburg Foundry and Machine Co., 130 First Ave., Pittsburg, Pa.
Jan. 6, '80.	Metcalf, Wm.,	Crescent Steel Works, 49th and R. R. Sts., Pittsburg, Pa.
Jan. 15, '84.	Meyran, L. A.,	Canonsburg Iron and Steel Co., Germania Bank Bldg., Pittsburg, Pa.
Sept. 18, '83.	Miles, Geo. K.,	Sec. and Treas. Charlotte Fur Co., Pittsburg, Pa.
Feb. 21, '82.	Milholland, J. B.,	Engine Builder, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Miller, Reuben,	Crescent Steel Works, Pittsburg, Pa.
May 19, '85.	Miller, Wilson,	Sec. Pittsburg Loco. Works, 18 Lincoln Ave., Allegheny, Pa.
Oct. 19, '80.	Milliken, A. C.,	Pottsville Iron and Steel Co., Pottsville, Pa.
Apr. 19, '81.	Moorhead, M. K.,	Moorhead-McCleane Co., Pittsburg, Pa.
Mar. 15, '81.	Morgan, Jas.,	2204 Carson St., Pittsburg, Pa.
Apr. 15, '90.	Morgan, Wm.,	2 Sixth St., Pittsburg, Pa.
Oct. 19, '86.	Morris, G. W.,	P. O. Box 56, Pittsburg, Pa.
Jan. 21, '90.	Morris, H. Saunders,	Westinghouse Electric Co., Pittsburg, Pa.

Date of Membership.		
May 15, '83.	Morse, H. C.,	Engineer, Edgemoor, Del.
Mar. 18, '91.	Mueller, Gustave,	Duquesne, Pa.
Dec. 19, '89.	Müller, C. F.,	606 Penn Building, Pittsburg, Pa.
Apr. 15, '80.	Munro, R.,	Boiler Manufacturer, 23d and Smallman Sts., Pittsburg, Pa.
Mar. 16, '80.	McCandless, E. V.,	Merchant, Pittsburg, Pa.
May 19, '85.	McConnell, John A.,	69 Water St., Pittsburg, Pa.
Mar. 15, '81.	McCulley, R. L.,	101 Fifth Ave., Pittsburg, Pa.
Feb. 22, '81.	McCune, John D.,	98 Fourth Ave., Pittsburg, Pa.
May 21, '89.	McDonald, John,	239 Forty-fourth St., Pittsburg, Pa.
Dec. 17, '89.	McDonald, C. J.,	314 Penn Building, Pittsburg, Pa.
Apr. 18, '87.	McDowell, Jas.,	Optician, Observatory Ave., Allegheny, Pa.
Mar. 19, '89.	McKean, R. A.,	812 Hamilton Building, Pittsburg, Pa.
Sept. 21, '80.	McKinney, J. P.,	60 Sheffield St., Allegheny, Pa.
Jan. 16, '83.	McKinney, R. M.,	Elizabeth, Pa.
Mar. 15, '81.	McLennan, Alex.,	56 Second Ave., Pittsburg, Pa.
Feb. 21, '82.	McMurtry, Geo. G.,	Pittsburg, Pa.
Feb. 17, '85.	McQuiston, Jas.,	26th and Railroad Sts., Pittsburg, Pa.
Mar. 15, '81.	McRoberts, J. H.,	400 Grant St., Pittsburg, Pa.
Apr. 15, '84.	McTighe, Jas. J.,	175 W. Carson St., S. S., Pittsburg, Pa.
Jan. 6, '80.	Naegeley, Jno.,	Eng. and Architect, Room 9, Renshaw Bldg., Liberty & 9th Sts., Pittsburg, Pa.
Jan. 19, '86.	Nevins, Richard, Jr.,	Seattle, Washington.
	Nichols, T. R.,	223 Allegheny Ave., Allegheny, Pa.

Date of Membership.		
Apr. 20, '80.	Nimick, F. B.,	Steel Mfr., Singer, Nimick & Co., Pittsburg, Pa.
Feb. 21, 82.	Noble, Patrick,	Pacific R. M. Co., 202 Market St., San Francisco, Cal.
May 19, '85.	Osborn, Frank C.,	King Iron Bridge and Mfg. Co., Cleveland, O.
Feb. 20, '83.	Paddock, Jos. H.,	Civil Engineer, Connellsville, Pa.
May 21, '89.	Paine, G. H.,	Swissvale, Pa.
Mar. 18, '84.	Painter, Park,	Iron Mfr., J. Painter & Sons, Pittsburg, Pa.
Nov. 20, '88.	Palmer, W. P.,	37 Beach St., Allegheny, Pa.
Sept. 18, '88.	Park, J. G.,	Americus, Georgia.
Jan. 6, '80.	Parkin, Chas.,	Parnassus, Pa.
Apr. 15, '84.	Parkin, Walter F.,	136 First Ave., Pittsburg, Pa.
Feb. 22, '81.	Patterson, Peter,	National Tube Works, McKeesport, Pa.
Nov. 15, '81.	Paul, J. W.,	Verona Tool Works, Seventh Ave. and Liberty St., Pittsburg, Pa.
Apr. 15, '84.	Paulson, Frank G.,	Hatter, Wood St., Pittsburg, Pa.
Mar. 15, '87.	Pease, Chas. T.,	Westinghouse Electric Co., Pittsburg, Pa.
Sept. 18, '83.	Peebles, Andrew,	Architect, Schmidt & Friday Building, Pittsburg, Pa.
Jan. 6, '81.	Pettit, Robt. E.,	Penna. R. R. Co., Altoona, Pa.
Nov. 20, '88.	Petitdidier, Lewis M.,	Fifteenth and Arapahoe Sts., Denver, Col.
Jan. 20, '80.	Phillips, F. C.,	Prof. of Chemistry, 59 Sherman Ave., Allegheny, Pa.
Jan. 16, '83.	Phipps, Henry, Jr.,	Carnegie, Phipps & Co., Ltd., Pittsburg, Pa.

Date of Membership.		
Dec. 20, '81.	Porter, John C.,	Spang Steel and Iron Co., Pittsburg, Pa.
May 17, '87.	Porter, John E.,	Iron Broker, 413 Wood St., Pittsburg, Pa.
Jan. 16, '83.	Prentice, W. J.,	Cement, Lime & Terra Cotta, 1009 Liberty St., Pittsburg, Pa.
Apr. 17, '83.	Price, C. B.,	A. V. R. R., Pittsburg, Pa.
Dec. 18, '88.	Purves, Jas.,	Munhall, Pa.
Jan. 6, '80.	Quincy, W. C.,	Mon. Cen. R. R., 3d Ave. and Fry St., Pittsburg, Pa.
Mar. 15, '81.	Ramsey, Jos., Jr.,	Asst. V.-Pres. C. C. C. I. & St. L. Ry., Cincinnati, Ohio.
Jan. 20, '80.	Reed, Jas.,	Supt. Schuylkill Div. P.R.R., Reading, Pa.
Jan. 20, '80.	Rees, Thos. M.,	Machinist, J. Rees & Sons, Pittsburg, Pa.
Jan. 6, '80.	Reese, Jacob,	400 Chestnut St., Philadelphia, Pa.
June 19, '88.	Reinmann, A. L.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 20, '85.	Reisinger, Chas.,	Sewickley, Pa.
May 15, '83.	Reno, Geo. E.,	90 Fourth Ave., Pittsburg, Pa.
Jan. 9, '80.	Rhodes, Joshua,	Penna. Tube Works, Pittsburg, Pa.
Jan. 6, '80.	Ricketson, John H.,	Founder, 6 Wood St., Pittsburg, Pa.
Apr. 19, '87.	Rider, Percy S.,	6 Ninth St., Pittsburg, Pa.
Apr. 15, '90.	Ritchie, Jas.,	7th Avenue Hotel, Pittsburg, Pa.
Jan. 17, '88.	Robbins, F. L.,	Penn Building, Pittsburg, Pa.
Jan. 7, '80.	Roberts, Thos. P.,	C. Engineer, 53 Beach St., Allegheny, Pa.
Jan. 7, '80.	Rodd, Thos.,	Penna. Co., Pittsburg, Pa.
Nov. 19, '89.	Ruhe, C. H. Williams,	102 Bluff St., Pittsburg, Pa.

Date of Membership.		
Jan. 17, '88.	Ruud, Edwin,	706 Penn Ave., Pittsburg, Pa.
Apr. 15, '84.	Scaife, O. P.,	Wm. B. Scaife & Sons, Structural Iron Works, 119 First Ave., Pittsburg, Pa.
Mar. 20, '83.	Scaife, W. Lucien,	Scaife Foundry and Mach. Co., Twenty-eighth and Smallman Sts., Pittsburg, Pa.
Sept. 20, '87.	Scaife, W. Marcelin,	336 Ridge Ave., Allegheny, Pa.
Apr. 15, '90.	Scheffler, Fred. A.,	Westinghouse Electric Co., Pittsburg, Pa.
Feb. 21, '82.	Schellenberg, F. Z.,	Elysian St., E.E., Pittsburg, Pa.
Jan. 6, '80.	Schinneller, Jacob,	M. E., Room 31, McClintock Block, Pittsburg, Pa.
Feb. 17, '85.	Schmid, Alb.,	Supt. Westinghouse Electric Co., Pittsburg, Pa.
May 15, '83.	Schook, Levi,	1st Ave. and Ferry Streets. Pittsburg, Pa.
Jan. 6, '80.	Schultz, A. L.,	Hiland Ave., E. E., Pittsburg, Pa.
Sept. 19, '82.	Schultz, C. J.,	Iron City Bridge Works, Pittsburg, Pa.
Nov. 15, 81.	Schwartz, F. H.,	5000 Liberty St., Pittsburg, Pa.
Mar. 18, '84.	Schwartz, J. E.,	61 Fourth Ave., Pittsburg, Pa.
Apr. 15, '90.	Scott, Chas. F.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 16, '83.	Scovell, Minor,	Engineer and Contractor, Nashville, Tenn.
Jan. 16, '83.	Seaver, J. W.,	79 Fremont St., Allegheny, Pa.
Apr. 19, '87.	Seymour, John E.,	Latrobe, Pa.

Date of Membership.		
Jan. 22, '89.	Shaw, A. G.,	5268 Carnegie St., Pittsburg, Pa.
Jan. 22, '89.	Shaw, W. W.,	County Engineer's Office, Pittsburg, Pa
May 19, '85.	Shelton, Thos.,	National Tube Works, McKeesport, Pa.
Nov. 18, '84.	Shepler, Cassius R.,	Banger & Natchez, S.S., Pittsburg, Pa.
Sept. 19, '82.	Sherzer, W.,	C. Eng., 209 Home Insurance Building, Chicago, Ill.
Nov. 24, '85.	Shultz, O. G.,	McKee's Rocks P. O., Pa.
Dec. 29, '87.	Simpson, Jas. H.,	Carnegie, Phipps & Co., Ltd., Pittsburg, Pa.
Sept. 21, '80.	Singer, Harton G.,	83 Water St., Pittsburg, Pa.
Sept. 21, '80.	Singer, W. H.,	Singer, Nimick & Co., Pittsburg, Pa.
Jan. 6, '80.	Slataper, Felician,	Chief Eng. Penna. Co., Pittsburg, Pa.
Jan. 21, '90.	Smith, F. S.,	Westinghouse Electric Co., Pittsburg, Pa.
Oct. 18, '87.	Smith, John W.,	159 River Ave., Allegheny, Pa.
Feb. 17, '80.	Snyder, Antes,	Eng. Right of Way, P. R. R., Blairsville, Pa.
Apr. 15, '84.	Snyder, W. P.,	Lewis Block, Pittsburg, Pa.
Jan. 18, '88.	Speer, B.,	Prof. of Physics, Pitts. High School, Pittsburg, Pa.
Feb. 17, '80.	Sprague, H. N.,	Porter & Co., Loco. Works, Pittsburg, Pa.
May 19, '81.	Stafford, C. E.,	Shoenberger & Co., Pittsburg, Pa.
May 19, '83.	Stevenson, David A.,	Civil Engineer, Room 6, Union Station, Pittsburg, Pa.
Jan. 19, '86.	Stevenson, W. S.,	Philadelphia Co., Roup St., Pittsburg, Pa.

Date of Membership.		
Nov. 21, '82.	Stewart, Geo. R.,	Gas Engineer, 43 Sixth Ave., Pittsburg, Pa.
Oct. 19, '86.	Stewart, J. H.,	48 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Stillburg, J. H.,	Architect, 20 Fifth Ave., Pittsburg, Pa.
Jan. 21, '90.	Stillwell, L. B.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 6, '80.	Strobel, C. L.,	M. E., 210 Home Insurance Building, Chicago, Ill.
Feb. 17, '91.	Stupakoff, S. H.,	Union Switch and Signal Co., Swissvale, Pa.
Oct. 19, '80.	Sutton, Thos.,	Pittsburg, Pa.
Feb. 20, '83.	Swan, Robert,	Civil Engineer, Allegheny Ave., Allegheny, Pa.
Apr. 19, '87.	Swenson, Emil,	Keystone Bridge Works, Pittsburg, Pa.
Feb. 19, '84.	Taylor, B. H.,	C. E., Rankin Station, Allegheny Co., Pa.
Apr. 20, '80.	Taylor, E. B.,	Genl. Supt. Penna. Co., Pittsburg, Pa.
May 18, '86.	Tener, Geo. E.,	Oliver Bros. & Phillips, New Castle, Pa.
Dec. 21, '81.	Thaw, Wm., Jr.,	Hecla Coke Co., 21 Lincoln Ave., Allegheny, Pa.
Dec. 21, '81.	Thomas, Alex.,	Sewickley, Pa.
Apr. 19, '89.	Thorsell, J. A.,	119 First Ave., Pittsburg, Pa.
Apr. 9, '91.	Tibbitt, C. H.,	68 Sixth Ave., Pittsburg, Pa.
Apr. 21, '85.	Todd, Jas.,	Chemist, 127 North Ave., Allegheny, Pa.
Mar. 18, '91.	Tone, S. L.,	19 Jackson Bldg., Pittsburg, Pa.
Nov. 24, '85.	Totten, Sidney H.,	Pittsburg, Pa.
Dec. 20, '87.	Travelli, Chas. J.,	Chemist, 333 Forty-second St., Pittsburg, Pa.
Jan. 6, '80.	Trimble, Robt.,	Penna. Co., Pittsburg, Pa.
Feb. 22, '81.	Utley, Edwd. H.,	A. V. R. R., Pittsburg, Pa.

Date of Membership.		
May 19, '85.	Verner, M. S.,	Supt. Citizens' Traction Co., 939 Penn Ave., Pittsburg, Pa.
Dec. 20, '87.	Verner, Henry W.,	8 Wood St., Pittsburg, Pa.
Apr. 18, '82.	Wainwright, J.,	C. E., 111 Fourth Ave., Pittsburg, Pa.
Apr. 19, '87.	Wainwright, J. R.,	P. O. Box 264, Pittsburg, Pa.
Jan. 6, '80.	Walker, J. W.,	Forty-seventh St. and A. V. R. R., Pittsburg, Pa.
Oct. 20, '85.	Walker, Arthur,	53 Main St., Zanesville, O.
Jan. 16, '83.	Warden, C. F.,	Greensburg, Pa.
Jan. 6, '80.	Weeks, Jos. D.,	Editor Amer. Manufacturer, Box 1547, Pittsburg, Pa.
Apr. 19, '87.	Weiskopf, Saml. C.,	Box 732, Pittsburg, Pa.
Feb. 21, '82.	Westerman, Thos.,	Verona Tool Works, Verona, Pa.
Feb. 20, '88.	White, H.,	21 Church Ave., Allegheny, Pa.
May 15, '83.	White, T. S.,	Penna. Bridge Works, Beaver Falls, Pa.
Jan. 6, '80.	Whittaker, Lee,	Covington, Ky.
May 18, '80.	Wickersham, S. M.,	C. Eng., Pittsburg, Pa.
Oct. 19, '80.	Wickersham, Thos.,	Mill Mgr., Park Bros. & Co., Pittsburg, Pa.
May 18, '86.	Wierman, Victor,	Eng. Pgh. Div. P. R. R., Pittsburg, Pa.
Jan. 21, '90.	Wigham, Wm.,	Camden, Pa.
Feb. 17, '80.	Wightman, D. A.,	Supt. Pittsburg Loco. Works, Box 76, Allegheny, Pa.
Jan. 6, '80.	Wilcox, John F.,	J. P. Witherow, Lewis Block, Pittsburg, Pa.
May 15, '87.	Wilkins, W. G.,	C. E., 23 Lincoln Ave., Allegheny, Pa.
Feb. 17, '80.	Wilson, Jno. T.,	Penn Bldg., Pittsburg, Pa.
Jan. 19, '86.	Wilson, Howard M.,	Founder, Craig St., Pittsburg, Pa.

Date of Membership.		
Jan. 18, '88.	Wilson, F. T.,	Jersey Shore, Lycoming Co., Pa.
Jan. 18, '88.	Wilson, W. R.,	811 Penn Bldg., Pittsburg, Pa.
Feb. 20, '88.	Winn, Isaac,	National Rolling Mill, McKeesport, Pa.
Jan. 6, '80.	Witherow, J. P.,	Eng. and Contractor, Lewis Block, Pittsburg, Pa.
Nov. 19, '89.	Wolffe, J. J. E.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 15, '84.	Wood, B. L., Jr.,	Mon. Dredging Co., 43 Sixth Ave., Pittsburg, Pa.
Sept. 21, '80.	Wood, R. G.,	Iron Mills, McKeesport, Pa.
Jan. 18, '88.	Wood, Jos.,	Genl. Supt. Transportation Pa. Lines, Pittsburg, Pa.
Jan. 18, '88.	Woods, Leonard G.,	East End Hotel, Pittsburg, Pa.
Mar. 20, '82.	Yeatman, Morgan E.,	Bridge Engineer, 11 Penna. Ave., Allegheny, Pa.
Jan. 6, '80.	Zimmerman, W. F.,	U. S. Electric Co., Newark, N. J.

CORRESPONDENTS.

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State Association of Engineers,	Norwich, Conn.
American Scientific Society,	219 River St., Troy, N. Y.
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American Society of Civil Engineers,	127 E. 23d St., New York.
Amer. Society of Mechanical Engineers,	60 Madison Ave., New York.
American Inst. of Mining Engineers,	Lock Box 223, New York.
Journal of Association of Engineering Societies,	73 Broadway, New York.
Railroad and Engineering Journal,	46 Broadway, New York.
Tichnischer Verein,	210 E. Fifth St., New York.
Engineering News,	Tribune Bldg., N. Y.
University of Illinois,	Champaign, Ill.
Library of Second Geological Survey of Pennsylvania,	907 Walnut St., Philadelphia, Pa.

Franklin Institute,	18 S Seventh St., Philadelphia, Pa.
Engineers' Club of Philadelphia,	1122 Girard St., Philadelphia, Pa.
Tichnischer Verein,	106 Randolph St., Chicago, Ill.
Railway Review,	Chicago, Ill.
American Engineer,	Chicago, Ill.
Western Society of Engineers,	Home Building, Chicago, Ill.
Civil Engineers' Club of Cleveland,	Cleveland, O.
Prof. C. N. Brown, Sec. Ohio Society of S. & C. Engineers,	Columbus, O.
Indiana Soc. of Civil Engineers and Surveyors,	Remington, Ind.
Engineers' Club of St. Louis,	St. Louis, Mo.
Engineers' Club,	Kansas City, Mo.
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B. Thompson,	Box 430, Chattanooga, Tenn.
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The Practical Mechanic,	Worcester, Mass.
Liverpool Engineering Society,	Colquitt St., Liverpool, England.
Iron and Steel Institute,	Lombard St., London, E. C.
National Association of Builders,	164 Devonshire St., Boston, Mass.
The Technic,	Ann Arbor, Mich.
Stevens Institute of Technology,	Hoboken, N. J.
Engineering and Mining Journal,	27 Park Place, N. Y.
Journal of Society of Arts,	John St., Adelphi, London, W. C.
Institution of C. E.,	25 Great George St., Westminster, London, S.W.

Society of Civil Engineers, Westminster Chambers, London, S.W.
London Patent Office, London, England.
Swedish Societo of C. E., Stockholm, Sweden.
Norsk Tiknisk Tideskrift, Christiana, Norway.
Associadad dos Engenheiros Civis Portuguezos, Lisboa, Portuguezos.
Sociadad Cientifica Argentina, Buenos Aires, S. A.
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Smithsonian Institution, Washington, D. C.